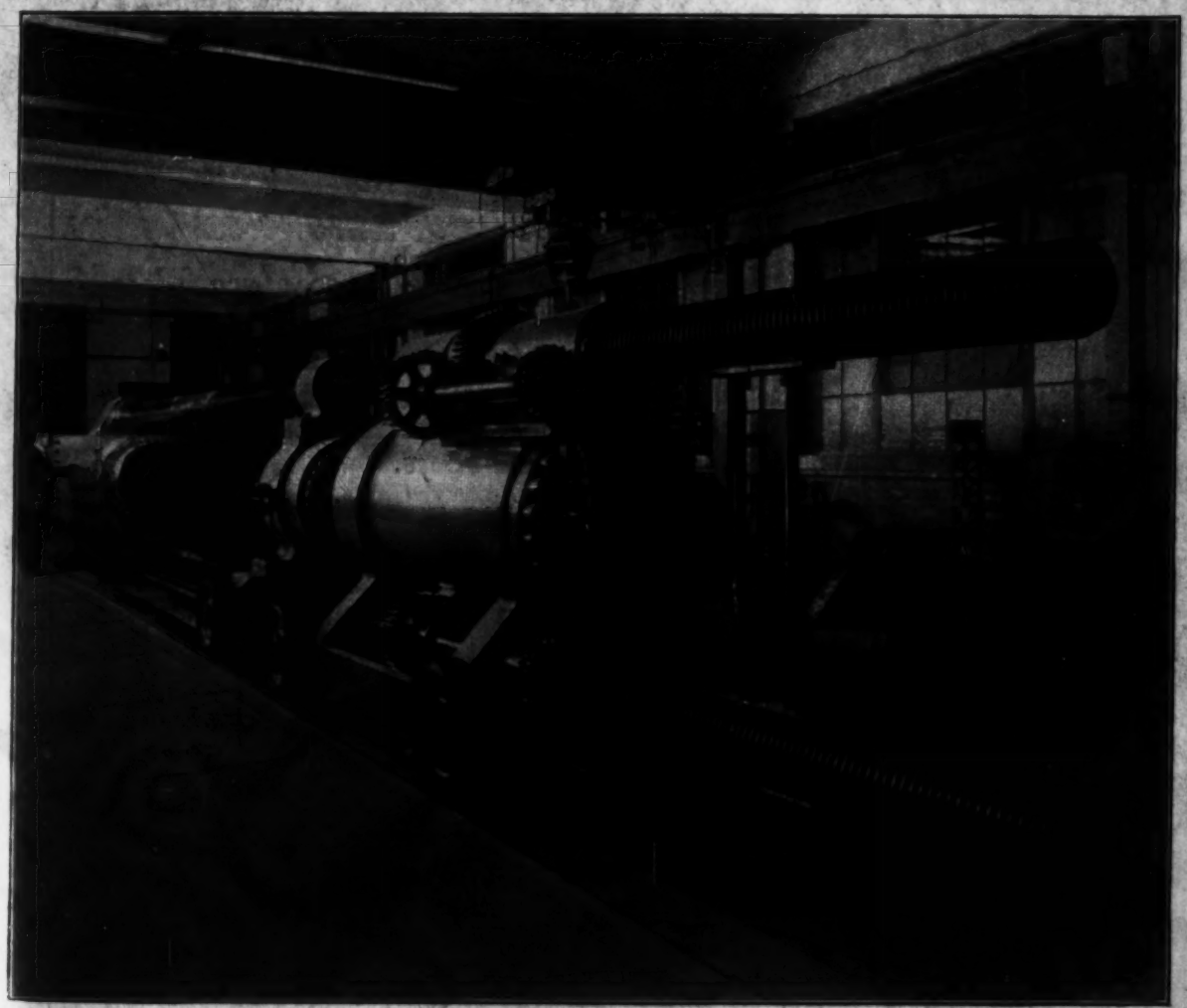
JUL 30 1928

MECHANICAL ENGINEERING



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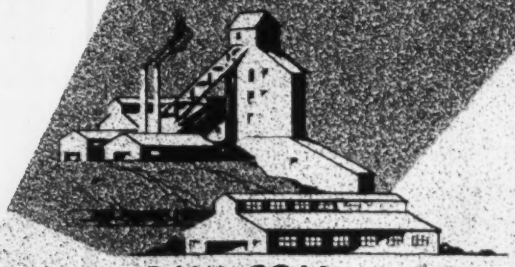


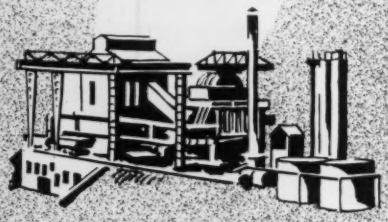
RAW COAL

How can we have Smokeless Cities Unless we have Smokeless Fuel?

EACH year America pays a cleaning bill, estimated to exceed $100,000,000, because of the smoke and dirt discharged by Industrial and Domestic chimneys.

Great as this loss appears, it is but a fraction of the tremendous underlying economic waste which attends the burning of raw coal — for coal is more than mere fuel to be burned. It is the most important raw basic material known to Industry and it should be so processed that each of its constituent elements may serve its most economic purpose.

When this is done, we shall have cheaper gas, cheaper steam, cheaper electricity and the only positive assurance of clean cities—a smokeless fuel for both Industrial and Domestic use.



LOW TEMPERATURE CARBONIZATION PROCESSED FUEL

International Combustion Engineering Corporation
International Combustion Building
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Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

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Volume 50 August, 1928 Number 8

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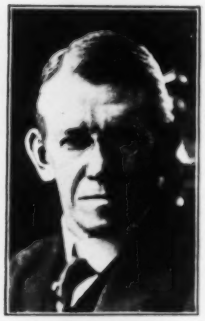

D. W. MEAD

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D. W. Mead is a consulting engineer, a member of the firm of Mead & Seastone, Madison, Wis., and of Mead & Scheidenhelm, New York City, and professor of hydraulic and sanitary engineering in the University of Wisconsin. He was graduated from Cornell University in 1884, receiving the degree of C.E. Mr. Mead was a member of the Red Cross Commission to China in 1914 for Flood Protection of the Hwai River Region, engineer of flood protection, Black River Falls, Wis., 1911–12, and is now a member of the Committee on Mississippi Flood Control of the United States Chamber of Commerce as well as of the University Advisory Committee on Flood Control to the House Committee on Floods.

B. R. Vanleer, upon his graduation from Purdue University in 1915, joined the faculty of the University of California, and is an assistant professor of mechanical engineering. When the United States entered the War he enlisted in the engineering corps of the Army and served overseas, being promoted to the rank of captain. He was cited for bravery and was also awarded the Croix de Guerre by the French Government. Professor Vanleer was the recipient of one of the John R. Freeman Traveling Fellowships and has just returned from a year's study of the great hydraulic laboratories of Europe. He holds the degree of M.E. from Purdue, M.S. in mechanical engineering from the University of California, and has studied at the University of Caen, France.

E. J. Mehren, vice-president since 1921 of the McGraw-Hill Co., Inc., and director of the McGraw-Hill Book Co., Inc., was graduated from the University of Illinois in 1906 with the degree of C.E. From 1907 to 1911 he was associated with the *Engineering Record* as associate editor, then becoming secretary and manager of the Emerson Co., New York, efficiency engineers, in 1911. A year later he became editor of the *Engineering Record* and in 1918 editor of the *Engineering News-Record*. He served as chairman in 1921 of the New York Conference of Business Paper Editors; as a member of the executive committee of the New York Building Congress, 1921–23; and as a member of the Committee on Commercial Engineering, U. S. Board of Education, 1922–23.

W. D. Ennis, vice-president of the Technical Advisory Corporation, New York, was graduated from Stevens Institute of Technology in 1897, later taking post-graduate work at the Western University of Pennsylvania. From 1900 to 1905 he served as engineer on the staff of John D. Rockefeller in various companies, including the American Linseed Co. He was then for two years associated with the American Locomotive Co. Later he served as professor of mechanical engineering at Brooklyn Polytechnic Institute, Columbia University, and the U. S. Naval Academy, as well as acting as consultant in mechanical engineering, specializing in industrial management. During the War he served in the Ordnance Department of the Army.

E. P. Warner, assistant secretary of the Navy for Aeronautics, received the degree of A.B. from Harvard University in 1916, and B.S. and M.S. from Massachusetts Institute of Technology in 1917 and 1919 respectively. From 1916 to 1926 he served as a member of the faculty at M.I.T., in charge of instruction in aeronautical engineering, being appointed professor in 1924. In addition he was engaged in consulting work for several airplane companies and in writing for the aeronautical and automotive press. His book on "Aerodynamics in Airplane Design" was awarded the medal of the Aero Club of France as the best technical aeronautical work of the year 1927.

C. P. Tolman, consulting engineer, New York, N. Y., was graduated from Massachusetts Institute of Technology in 1902 with the degree of B.S. Until 1906 he was associated with the Christensen Engineering Co., Milwaukee, resigning to become chief engineer of the Union Specialty Co. From 1907 to 1923 he was engaged in general consulting practice in New York City, then becoming chief engineer and chairman of the manufacturing committee of the National Lead Co., New York. Mr. Tolman is the author of many addresses and papers, particularly on the prevention of lead poisoning. He is a member of several scientific societies and a past-president of the National Safety Council.

This Month's Cover shows the Emery testing machine at the Bureau of Standards in Washington. This machine is for loads of 1,150,000 lb. tension and 2,300,000 lb. compression on specimens of any length up to 33 ft. and is in constant service on research work for the Bureau. An account of the inventions and achievements of Albert Hamilton Emery, the designer of this machine, will be found in this issue, page 654.

MECHANICAL ENGINEERING

Volume 50 August, 1928 No. 8

The Economic Field for Small and Medium-Size Diesel Engines

Applications in the Marine, Automotive, and Stationary Fields—Fundamental Factors Determining the Desirability of Installing Diesel Engines—Cost of Producing Diesel Power—Need for Authoritative Data

By HARLAN A. PRATT,[1] NEW YORK, N. Y.

POWER is the great force that has released mankind from industrial slavery. The late Dr. Steinmetz ventured the opinion that in time a two-hour working day would be sufficient for the average industrial worker to complete his allotted tasks. The fundamental prosperity of this country is due to the widely distributed use of power. A workman who today has at his command one horsepower of energy has multiplied his productive capacity by ten, and we may appropriately call him the boss of ten mechanical slaves. The prime-mover strength of the United States increased from sixteen million horsepower in 1902 to fifty-two million in 1922. At the same time the wealth of the country increased from eighty-eight billions to three hundred and twenty billions.

It is therefore not surprising that the Diesel engine has received the attention and publicity it has. This engine, invented in 1892 by Rudolf Diesel, was developed and patented in Germany, but owing largely to the cumbersome and expensive forms in which it appeared, it failed to gain any real recognition until the expiration of the fundamental patents about 1911. Little attention was given it in the United States until the early part of this century. Today there are upward of forty American manufacturers producing Diesel engines. The engine has long since passed from an experimental stage. We now have in this country over three million horsepower installed in Diesel engines. The Bureau of the Census gives the output of Diesel engines as 89,000 hp. in 1921, 198,000 hp. in 1923, and 409,000 hp. in 1925. It is estimated that the production in 1926 and 1927, on which the Government has not yet officially reported, will run close to the 1925 figure.

The fundamental reason that the Diesel engine has taken, and will continue to take, its place in industry and transportation is that it is the most efficient converter of the latent-heat energy in fuel into active mechanical energy. Its thermal efficiency, which is the ratio of heat utilized to heat contained in the fuel, is approximately 33 per cent, and this is true even in horsepowers as low as 25 to 50. This ratio of useful energy can be considerably increased in certain cases by the utilization of the waste heat in exhaust heaters, boilers, and exhaust turbines. Under such conditions the thermal efficiency may be increased to over 50 per cent.

Contrast this high efficiency with our steam plants. For example, according to a statement in the *Electrical World*, quoting the late General Tripp of the Westinghouse Electric and Manufacturing Company, "The thermal efficiency of the largest steam-turbine plants is 16 per cent." Since then some of these plants have been built to give as high as possibly 20 per cent. The usual thermal efficiency of a 1000-hp. steam plant is around 10 per cent. Steam units of the size discussed in this paper vary in efficiency from 3 to 10 per cent. Perhaps 5 to 6 per cent is a good average. In other words, the average steam engine requires approximately 25,000 B.t.u. of heat to develop one horsepower-hour. A modern Diesel engine will develop a horsepower-hour from a quantity of fuel oil containing 8000 B.t.u. or less. This amount of oil weighs a little more than 0.4 lb. and will not quite fill an ordinary drinking glass.

Field of Application of Diesel Engines

The field of application of Diesel engines from the smallest size up to those of 500 to 600 hp. is broadly divided into two classes:

1 Marine applications
2 Engines for land service—subdivided into:
  a Engines for automotive service
  b Engines for stationary work.

In the marine field the Diesel engine has quickly forged to the front; for example, over 50 per cent of the world's ship construction in the years 1926 and 1927 was equipped with oil engines. Confining ourselves to the discussion of the smaller units, we find that the ships taking these units today are the fishing boats, tugboats, work boats, ferry boats, small lighters, dredges, yachts, coast patrols, etc. It is almost safe to say that no boats in this class are built without considering the use of a Diesel engine. These sizes of Diesel engines are particularly applicable to marine work, as they show in the majority of cases great economy over any other power. The saving in fuel alone generally justifies the cost of the Diesel engines, and this saving in many cases can be augmented by a saving in the crew.

Unusual results have, for example, been obtained in tugboat service. A recent installation of two 350-hp. Diesel engines in the Diesel-electric tug *Meitowax*, owned by the Long Island Railroad, was compared with a modern steam oil-burning tug of the same size, and operating under the same conditions, on a 24-hour-day test. The figures published showed the daily fuel consumption on the Diesel tug of 480 gal. (cost, $24) and on the steam

[1] Manager, Oil and Gas Engine Dept., Ingersoll-Rand Co. Mem. A.S.M.E.

Presented at the National Oil and Gas Power Meeting, State College, Pa., June 14 to 16, 1928, under the auspices of the A.S.M.E. Oil and Gas Power Division, The Pennsylvania State College co-operating.

A 600-HP. OIL-ELECTRIC LOCOMOTIVE USED IN LUMBERING OPERATIONS BY THE RED RIVER LUMBER CO. AT WESTWOOD, CALIF.

tug of 2314 gal. (cost, $104), a ratio of 4 to 1. Furthermore, a saving of $14.28 per day was made in the crew, the total saving on wages and fuel being estimated at over $30,000 per year. In addition, there is the great convenience of taking on fuel only once in 15 days instead of once every three days. In general, this saving holds true in all marine work, and the Diesel engine is fast replacing steam and gasoline engines wherever the service is of considerable duration.

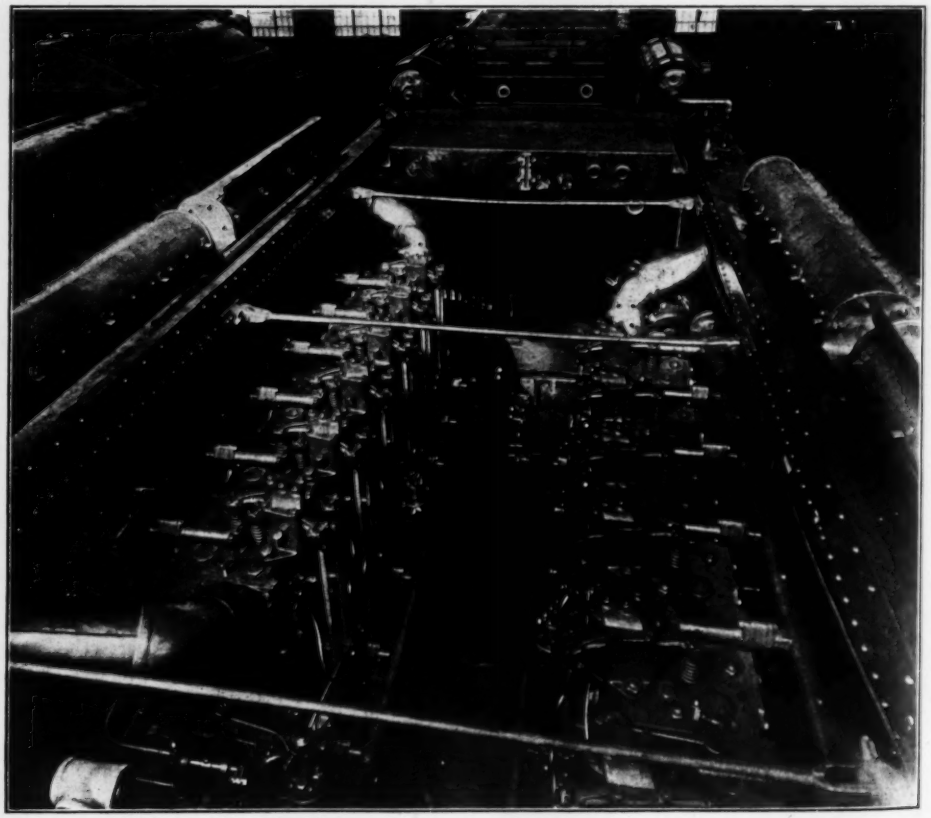
ENGINES FOR AUTOMOTIVE SERVICE

Coming to the consideration of engines for automotive service, we find attention is being given to the development of the Diesel engine for trucks and tractors, and even in the airplane field study is being given to the development of a proper Diesel engine. For locomotives, rail cars, shovels, and dragline buckets a big start has already been made.

In a paper presented before the Metropolitan Section of the A.S.M.E. on April 17, entitled "Performance Records of Oil-Engine Locomotives," the author, Hermann Lemp, stated that there had been installed up to January, 1928, in the United States, twenty oil-electric locomotives, and that the oil-electric locomotive was the only oil locomotive on standard-gage railroad tracks which had any service records to offer in this country, although abroad a 1000-hp. locomotive with mechanical transmission had been in operation on the Russian railways since March, 1927.

The report of the Committee on Diesel Locomotives of the International Railway Fuel Association made at Chicago, May 10-13, 1927, as analyzed by Mr. Lipetz in his very complete paper, "The Present Status of the Oil Electric Locomotive," read before the American Railroad Association in June, 1927, comes to the conclusion that a 30 per cent saving in switching and operating expenses can be made over steam operation; and that for branch-line service a 50 per cent saving can be made with Diesel rail cars.

The oil-electric locomotive is a self-contained unit, and may therefore be singly and step by step introduced in a railway system in the replacement of worn-out steam equipment, without change of personnel or facilities. This fact should encourage its introduction long before complete

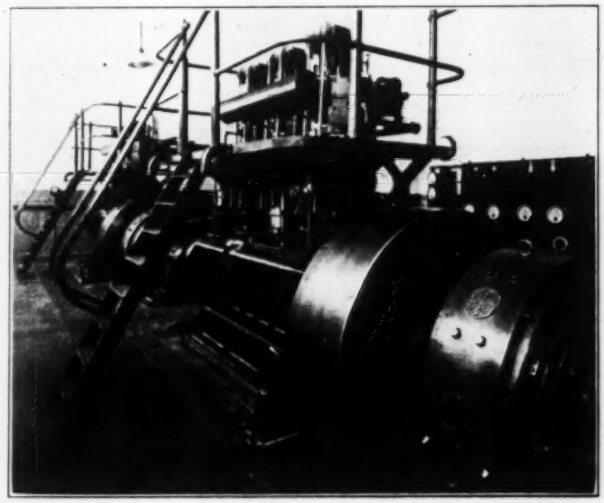


LOOKING DOWN INTO THE ENGINE COMPARTMENT OF A 600-HP. OIL-ELECTRIC LOCOMOTIVE
(Shows two 300-hp. oil engines direct-connected to generators which furnish power for motors on the locomotive axles.)

electrification, a certain density of traffic being necessary to make the latter practical.

While it is in connection with the high load factor that the oil-electric locomotive shows its greatest economic superiority over steam—for example, where employed for continuous duty in two and three 8-hour shifts, covering 24-hour performance—an oil-electric locomotive will in most cases pay for itself in three years, and will at the same time furnish more acceptable service to the public. However, there is a field for light service on 8-hour shifts where local conditions demand freedom from smoke and noise. Public welfare, more than the economic saving over steam that will be realized, is here the determining factor in selecting the oil-electric locomotive.

Several hundred Diesel-operated shovels and dragline units were built in the past year in the United States. While the cost of the Diesel engine is considerably more than that of the gasoline engine, the saving in the operation of 100-hp. units is approximately $1.50 per hour, based on 20-cent gasoline and 6-cent fuel oil, and it is only a question of determining the number of hours the unit will operate to show the advantage of the Diesel engine.



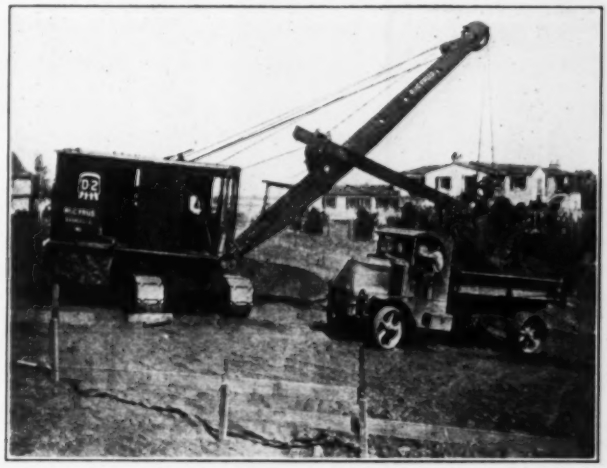
GENERAL VIEW OF THE OIL-ENGINE POWER PLANT OF THE WATCH TOWER BIBLE AND TRACT SOCIETY OF BROOKLYN, SHOWING TWO 170-HP. OIL ENGINES DIRECT CONNECTED TO ELECTRIC GENERATORS

Considerable care must be used in pointing out the economic field for the Diesel engine for stationary service. A source of power is decidedly a problem in economics. Of the prime movers in the country today about 40 per cent are installed in central stations and about 60 per cent in private plants. Great central stations are not users of Diesel engines on account of the sizes of the units, but for smaller plants and for reinforcing existing central-station lines the Diesel engine has been extensively adopted; 17.8 per cent of the Diesel-engine horsepower installed in 1926 was in central stations according to an article in *Power*, January 11, 1927. It is interesting to note that the remainder of the business was divided as follows: Marine, 25.9 per cent; oil-pipe-line companies, 20 per cent; water works and irrigation, 4.9 per cent; refrigerating plants, 4.7 per cent; mines and quarries, 4.3 per cent; general industries, 22.4 per cent.

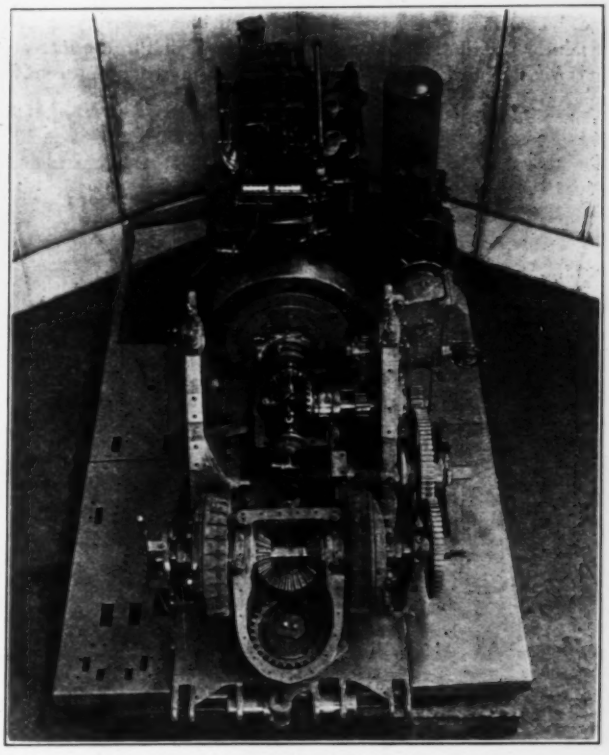
The above figures, as well as lists of engine owners, give ample evidence that among power users the field of the Diesel engine is not limited to any one industry or to any particular locality.

A user of power should carefully consider all sources available and select the one that will give him ample and dependable power that will be the best and cheapest compatible with his special needs. Generally speaking, the available sources of power, besides Diesel engines, for use in the sizes we are discussing are water power, producer-gas power, steam engines, turbines, and purchased electric power.

If there is central-station power available, this should logically always be considered, and a decision made as to the desirability of buying power or installing a private plant.

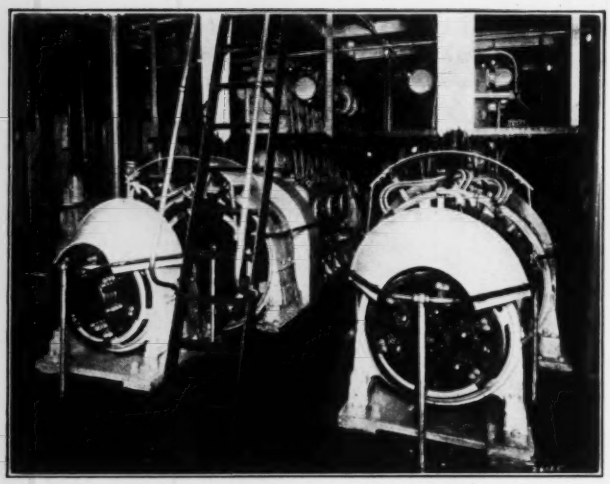


REVOLVING SHOVEL, DIESEL DRIVEN, AT BASEMENT-EXCAVATION WORK NEAR BEVERLY HILLS, CALIF.



DIESEL ENGINE AND MACHINERY USED IN REVOLVING SHOVEL SHOWN ABOVE

The feasibility of water power for small private plants is determined by special conditions, which are in the main unfavorable to much future development, although there are cases where this is the logical power if the water supply is available and the cost of machinery is not too great.



OIL-ELECTRIC INSTALLATION ON N. Y. CENTRAL TUGBOAT NO. 34

(Two 6-cylinder, 14 × 19-in. oil engines, which develop 400 hp. at 265 r.p.m. Each engine is direct connected to a 270-kw. generator and a 30-kw. exciter. The generator supplies power for a 650-s.hp. double-armature propulsion motor. Exciters supply power to operate motor-driven pumps and auxiliaries and also excitation for main motor and generators.)

Producer-gas power in the past held great promise, and many plants were installed. Today its application is restricted to a very limited field, such as large units in steel mills, glass plants, etc. The small producer-gas engine, and its accompanying gas-producer installation, have virtually passed, due to the increase in the cost of coal, scarcity of skilled labor required, and excessive upkeep of the gas-generating equipment.

Steam power is admittedly inefficient, and is only desirable in cases where a really appreciable amount of process steam is required.

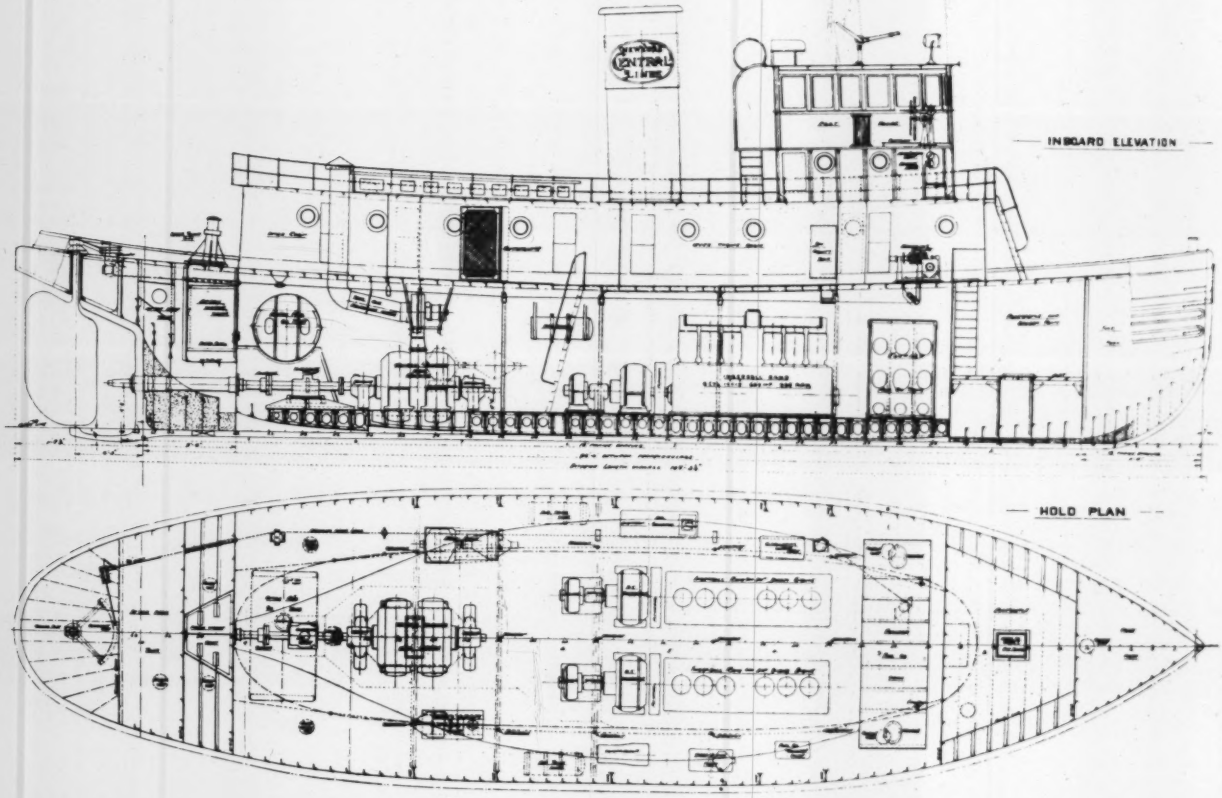
Thus it is seen that today a user of power should carefully consider the Diesel engine. In addition to the high thermal efficiency, the reliability, the practical mechanical construction, and the satisfactory operation of representative makes of Diesel engines are giving more and more confidence to prospective purchasers.

The endeavor of this paper is not so much to discuss the actual cost of developing a horsepower-hour or a kilowatt-hour with the Diesel engine, as to lay down the fundamental factors determining the desirability of installing Diesel engines; for the successful development of the industry depends upon the intelligent cooperation of manufacturers with purchasers in the determination of the proper application of this prime mover.

As a rule, load factor is the determining feature as to whether or not a Diesel engine should be installed. The peak-load requirements will decide the size of the power plant. The careful determination of the load factor and number of hours of operation will give the total power units to be produced in a given time. The two fundamentals—size and cost of the Diesel plant, and the number of units of power to be produced—having been determined, the actual cost of the energy can be computed.

COST OF PRODUCING DIESEL POWER

The cost of producing power will be made up of the following items: Fuel oil, lubricating oil, labor, maintenance, and capital charges. The correct analysis of these factors will determine the cost of the Diesel power in comparison with other available power.



HOLD PLAN AND INBOARD ELEVATION OF N. Y. CENTRAL TUG NO. 34

TABLE 1 DISTRIBUTION OF POWER COSTS IN A TYPICAL DIESEL ENGINE POWER PLANT

	Total cost	Cost per kw-hr.
Fuel oil	$4,730	$0.0050
Lubricating oil	531	0.0005
Labor	5,000	0.0052
Maintenance, 2 per cent	500	0.0006
Fixed charges, 11.72 per cent	3,800	0.0039
Total	$14,561	$0.0152
Total, less fixed charges	$10,761	$0.0113

PLANT

Engines	Three, each 120 hp.
Kilowatts	240
Cost per kilowatt	$135
Production	946,080 kw-hr. per year
Load factor	50 per cent
Fuel-oil cost	.5 cents per gal.
Lubricating oil cost	55 cents per gal.
Kw-hr. produced per gallon of fuel oil	10

TABLE 2 ACTUAL RESULTS OF PLANT INSTALLED

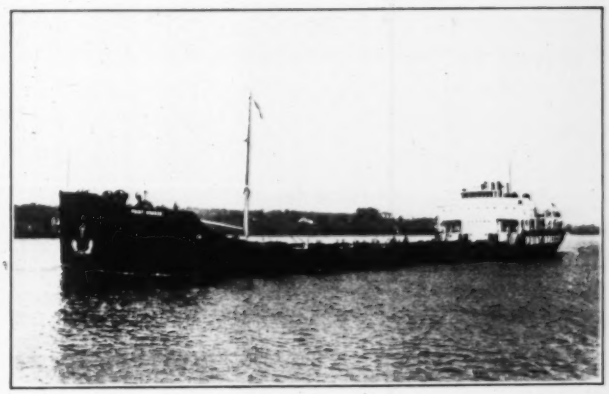
	Total cost	Cost per kw-hr.
Fuel oil	$9,939	$0.005640
Lubricating oil	976	0.000554
Labor	5,246	0.002960
Maintenance	1,289	0.001300
Fixed charges, 10 per cent	6,000	0.003410
Total	$23,450	$0.013864
Total, less fixed charges	$17,450	$0.010454

PLANT

Engines	Two, each 330 hp.
Kilowatts	440
Cost per kilowatt	$137
Production	1,761,000 kw-hr. per year
Load factor	46 per cent
Fuel-oil cost	6½ cents per gal.
Lubricating-oil cost	50 cents per gal.
Kw-hr. produced per gallon of fuel oil	112

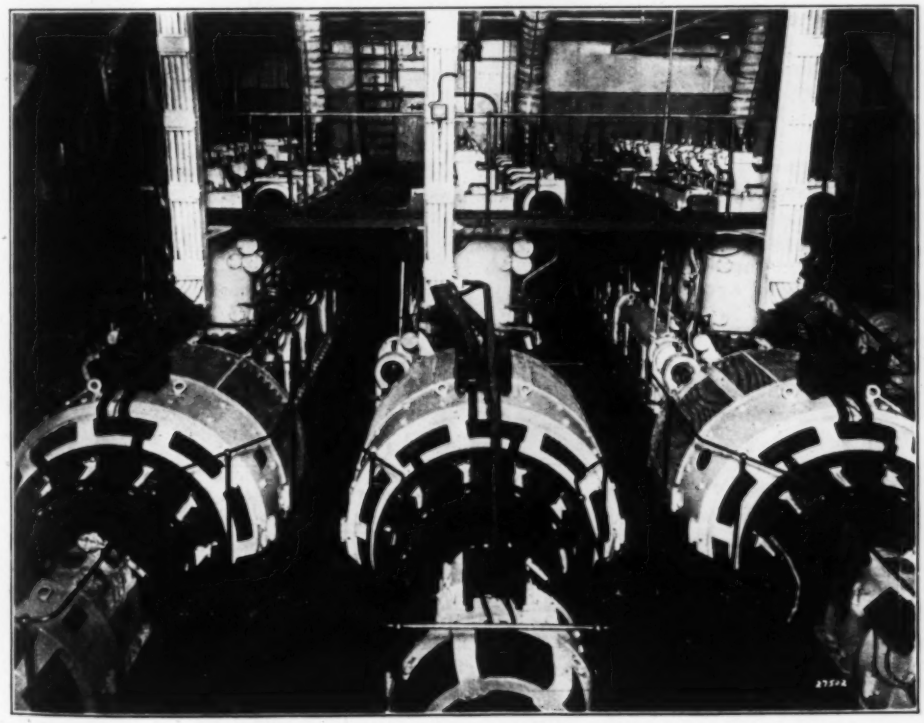
Table 1, which has been widely circulated by a prominent manufacturer of Diesel engines and is based on its experience, covers a typical plant.

It is interesting to compare the figures in Table 1 with those in Table 2, which latter are actual figures on a plant installed by another Diesel manufacturer. The first manufacturer advertises that power, less fixed charges, can be produced for $0.0113 per kw-hr., while the second gives figures showing that a plant in actual operation produces power for $0.0104 per kw-hr. The closeness with which these figures check is a credit to the industry.



M. S. Point Breeze WHICH IS DRIVEN BY THREE 600-HP., 6-CYLINDER, 17¾ × 22-IN. OIL ENGINES

A list of installations of any one of the large manufacturers today will show the dependability of Diesel engines. In the oil fields there are thousands of horsepower directly connected to reciprocating pumps. The service is continuous, and the engines run for many weeks without shutting down. There are cement plants operating continuously where the cost of producing current is under one cent a kilowatt-hour. There is a record of one engine in a glass plant in New Jersey having run eight months and twenty-three days without shutting down. Ice plants are producing ice at a fuel cost for power at twenty-five cents a ton. Compressor plants are delivering 1000 cu. ft. of air per minute at 100 lb. pressure for 1.2 cents. Installations of great diversity of application are paying for themselves in one, two, and three years.



ENGINE ROOM OF *M. S. Point Breeze* SHOWING THE THREE 600-HP. 17¾ × 22-IN., 225 R.P.M., 6-CYLINDER ENGINES

And yet there is a lack in the Diesel-engine industry of readily available data that are both reliable and convincing to the prospective purchaser. It is true that Diesel manufacturers have their own sales data; however, these figures are often questioned not only by salesmen of competing sources of power, but—and what is often more damaging—statements of one Diesel-engine salesman are disputed by another Diesel salesman, and confidence in the Diesel idea is thereby destroyed.

To correct this situation the industry should take steps to gather together all present available information, of which there is a considerable amount and should extend aid to the Power Cost Committee of the Oil and Gas Power Division of the A.S.M.E. in its work of collecting data on the cost of producing power in existing Diesel plants.

Work of Bureau of Standards on Friction and Lubrication[1]

FOR some years past both the Bureau of Standards and the Bureau of Mines have been engaged in testing and investigating lubricants and determining the efficiency of machinery, this work being scattered through various divisions of the two Bureaus. In order to consolidate and further develop this work, a Friction and Lubrication Section was recently organized in the Heat and Power Division of the Bureau of Standards, and the routine testing formerly conducted by the Bureau of Mines was officially transferred to the Bureau of Standards.

The study of friction losses may be considered part of the general program of the Department of Commerce for the elimination of waste in industries. Only a small amount of the mechanical power generated for industrial use (i.e., exclusive of illumination) is actually converted into useful work, such as permanent raising of weights against gravity; almost the entire amount is converted or dissipated into heat through the medium of friction.

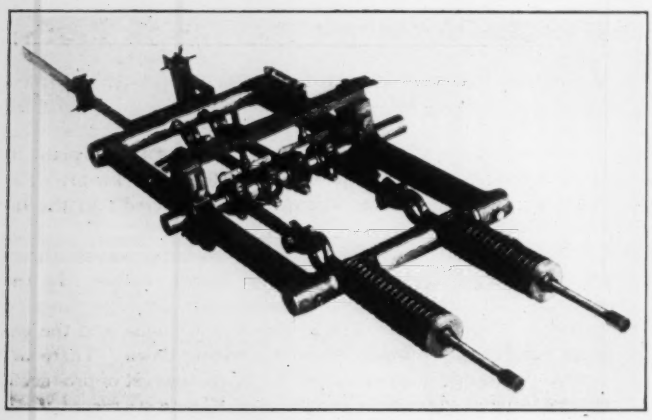


FIG. 1 SPECIALLY DESIGNED MACHINE FOR MEASURING FRICTIONAL LOSS IN JOURNAL BEARINGS WHEN OPERATING UNDER DIFFERENT CONDITIONS OF LOAD, SPEED, AND VISCOSITY OF LUBRICANT

The principal activities of the Friction and Lubrication Sections that are supported by direct Congressional appropriations to the Bureau of Standards consist in supplying technical information and conducting routine tests of lubricants. Information is requested by other Government departments confronted with lubrication difficulties, by the public, by educational institutions and scientific societies. The Bureau cooperates actively with the various sub-committees of the American Society for Testing Materials, which are concerned with standardization of the various tests on lubricating oils and greases; and with the committees on lubrication and cutting fluids of The American Society of Mechanical Engineers, the American Electric Railway Association, the Federal Specifications Board, and other organizations.

The testing of lubricants for compliance with Federal specifications is conducted for practically all Government departments, except the Army and Navy, in order to place the purchasing of lubricants on the most economical and efficient basis. In addition, referee tests are made for the public where the results obtained by commercial laboratories are under dispute; also various tests are made on lubricants for the oil companies and others as a means of checking the accuracy of their own instruments. Standard samples of oil whose viscosities have been accurately determined by the Bureau of Standards are available at a very slight cost, and have helped to bring about uniformity in the industries. The fees collected for the routine testing are turned back to the Treasury Department. Incidentally, in connection with routine testing, a number of instruments and methods of importance to the petroleum industry have been standardized, and new methods and apparatus have been developed and reports thereon published, all of which helps to create a better understanding between the producer and consumer of petroleum products and to facilitate their transactions.

While the saving that the Bureau can bring about in the cost of oil to the consumer or in the cost of producing oil through standardization of specifications and tests is easier for the layman to understand than some of the more technical problems in this field, yet the Bureau probably performs ultimately a greater economic service through its investigations of the fundamental laws governing friction loss in bearings which provide the data necessary for more efficient design and operation of machinery. These investigations are conducted for the most part either through funds transferred from other Government departments which are requesting specific investigations, or in cooperation with outside organizations on the research associate plan. Examples of these research problems are:

1 A general study of certain properties of lubricants, such as consistency of grease, oiliness of lubricating oils, etc., where scientific knowledge has not kept pace with industrial requirements

2 Development of a machine for testing transmission lubricants for automotive trucks at the Army's request

3 Study of oil flow at low temperatures in aircraft engines at the request of the Navy Department

4 Comparison of the efficiency of different types of spur-gear and worm-gear drives for electric-railway trucks, in cooperation with the A.E.R.A.

5 Fundamental research on journal-bearing performance in relation to speed, load, viscosity of lubricant, and mechanical design, in cooperation with the A.S.M.E.

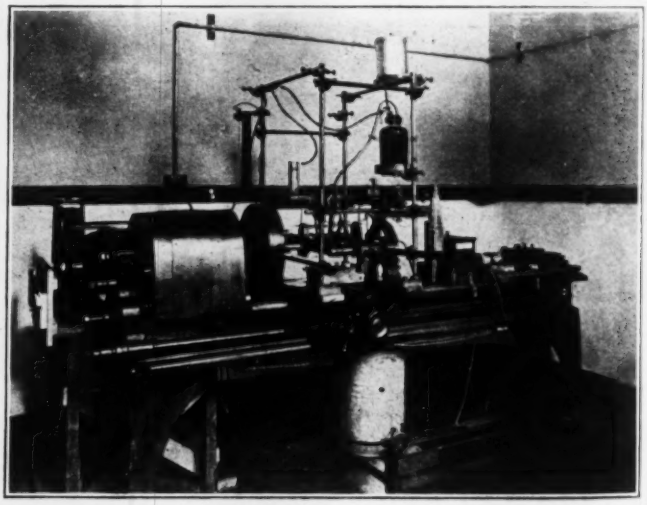


FIG. 2 GENERAL VIEW OF MACHINE SHOWN IN FIG. 1 MOUNTED ON A SHAFT SET IN A LATHE

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

Safety and Production[1]

An Engineering and Statistical Study of the Comparative Relationships Between Industrial Safety and Production

Reviewed by C. P. TOLMAN[2]

PURPOSEFUL management must include executive attention to organized safety work for good production results. This is the conclusion reported by the American Engineering Council. It covers a study of fourteen thousand plants employing two and one-half million men over a period of operation totaling upward of fifty-four billion man-hours.

The conclusion is substantiated by 83 per cent of the total experience available for analysis, almost one-tenth of the total industrial workers in the United States. Over 60 per cent of these men are employed by firms, "recognized as outstanding among American industries, nationally known and credited with having progressive management."

The alarming increase in the number and severity of industrial accidents since 1920 caused the National Bureau of Casualty and Surety Underwriters to propose and support the searching investigation which has proved beyond question that industrial "safety" and sound management are inseparable—that waste of life and limb goes hand in hand with inefficient production, while conservation of life and limb leads inevitably to greater economy and efficiency in manufacture as a whole.

The industrial executive may take the report of this investigation as though it were made expressly for his own plant. That which has been discovered is a new industrial law and, as such, it applies to the individual plant in the same manner as it applies to industry in general.

Data Valuable to Industrial Executives

The data, which cover twenty industries and sixty product groups, develop production factors well worth the thoughtful consideration of industrial executives. In many instances, the executive or stockholder will find information relating either directly or so closely to the operating results of his own plant that he may, by comparison, determine the effectiveness of his management. It is astonishing, to say the least, how widely these results vary among different units in the same industry. It is particularly interesting that the widest variations are in those industries where productive results have decreased, and accidents have increased both in frequency and in severity.

The period covered is notable because all industries were trying to increase the production per man-hour on account of the higher scale of wages. While this has increased the work of the committee, it has at the same time made their report of particular value. All executives are faced with the necessity of greater output per man-hour because of the higher wage scale, and the report is full of informative data of this character.

Cement Industry—By-Product Coke—Telephone and Telegraph

The data of the cement industry are particularly striking. They are complete for a period of six years, thanks to the Bureau of Accident Prevention and Insurance of the Portland Cement Association, whose statistics cover 120 plants, 97,000,000 man-hours and 90 per cent of the entire cement output of the United States. During the period of six years reported, there is an increase in productivity of 32 per cent, accompanied by a decrease of 29 per cent in accident frequency and a decrease of 30 per cent in accident severity.

Between 1916 and 1924, 55 by-product coke companies, representing over 75 per cent of the total tonnage, show an increase of 107 per cent in production per man-hour, accompanied by a reduction of 75 per cent in accident frequency and 37 per cent decrease in severity.

A telephone and telegraph system, employing 82,000 workers from 1922 to 1925, increased production per man-hour 26 per cent and reduced accident frequency 62 per cent. So the facts range through 20 industries and 60 product groups, from marked increase in production accompanied by decrease in accidents, down to industries in which production per man-hour has decreased and accident severity increased. Among the former we find notably successful concerns and industries—and among the latter the less fortunate.

Relationship Between Safety and Production

So strong are the theoretical grounds for believing the relationship between safety and production to be reciprocal and inseparable that the conclusion of the Committee is not at all surprising. Albert W. Whitney, in his "Statement of the Problem," writes as follows:

> As long ago as 1919, the National Safety Council was definitely working on the problem. It gave a dinner at the Engineer's Club in New York, on November 17, of that year, attended by some forty of the leading engineers of the country, at which this subject was the topic of discussion. It was on this occasion that S. J. Williams, at that time engineer of the National Safety Council, enunciated a statement of the nature of the relationship between safety and efficiency which will always be a classic.
>
> Mr. Williams said in effect: Suppose a box falls off a loaded truck and kills a man. For every such case which results in a physical injury there will be perhaps a hundred cases where a box falls off without injuring any one. But in every one of these hundred cases either the box will be broken or in any case the truck will have to be stopped and the load repiled. While, therefore, there will be only one case of physical injury, there will be a hundred and one cases of inefficiency. An accident is something gone wrong and it can result only from causes which have their effect over a far wider field than that of the immediate accident itself. The physical injury is only the spectacular evidence of some underlying maladjustment in the same way that a headache is only an alarm bell that calls attention to something that is wrong within.

The comparison between industry and the human body is very close. In the industrial body, management represents the brain, and the manufacturing equipment the physical structure and limbs. The workers correspond to the sensory nerve termini. The connection of these workers to the industrial brain must be provided by the safety and personnel organization. If, in Mr. Williams' illustration, the injury suffered by the worker is not reflected through the safety organization to the industrial "brain"—the manufacturing fault fails to register and so continues uncorrected. The waste—human and material—goes on.

Can Industrial Accidents Be Controlled Under Modern Conditions of Production?

A clean-cut, affirmative answer is given to this question. The

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[1] A Report by the American Engineering Council. Harper and Brothers, New York and London, 1928. Cloth, 6 × 9 in. 414 pp., diagrams.

[2] Consulting Engineer, New York, N. Y. Past President, National Safety Council. Mem. A.S.M.E.

answer includes a quotation from "Industrial Safety Organization," by Lewis A. DeBlois, citing experiences of the United States Steel Corporation and of E. I. du Pont de Nemours & Co. These tables show experiences in departments in which as few as 109 and as many as 6000 men are employed. In one department employing 300 men, four years and three days passed without accident, a total of 360,900 man-days. A department employing 6000 men shows 414,000 man-days without accident. In all, 33 departments are cited, each with a conspicuous record.

The findings of the Committee in answer to the question of the controllability of accidents are based on two tabulations of data, which are referred to as follows:

> .....the experience of 513,083 employees, comprising 19 different industrial groups. In every case, for varying periods of from three to ten years, there has been an increase in production and a decrease in accident frequency and accident severity. That is, production has been controlled to increase, and accidents have been controlled to decrease.
>
> Much the same evidence is shown by the performance of eight other industrial groups representing the experiences of 332,548 employees. Production increased and accident severity decreased. While accident frequency increased, it was in every case at a substantially lower rate than production increased.

Referring to controllability of accidents, in his "Statement of the Problem," Mr. Whitney writes the following: The United States Steel Corporation in thirteen years has decreased its accidents 86 per cent; The Union Pacific Railroad has a safety record for shop employees that is over five times as favorable as the average of the other large railroad systems of the United States; the Clark Thread Company has a record of nearly 10,000,000 man-hours without an accident; one of the plants of the du Pont Company with 65 employees has a record of eleven years with only one accident, and that a relatively minor one.

Engineering Revision

Dr. Lucian W. Chaney, speaking at the National Safety Council Meeting in 1919 (earlier mentioned), contrasted engineering supervision with what he aptly called "engineering revision." He applied the new expression to that fundamental character of design whereby new equipment and methods are suited to new requirements in character and capacity. Former practices and habits are permitted to influence such revision only to the extent that they can be substantiated by facts. Dr. Chaney's paper is cited at this point because it appears from the report that those concerns who have practiced "engineering revision" stand at the head of the list with respect to production increase accompanied by accident decrease. This suggests the question as to whether the plants at the bottom of the list are experiencing decreased production and increased accidents because of forcing equipment which is obsolete with respect to present production requirements.

The Whole Story Told in 37 Pages

The form in which the report is presented calls for special comment apart from the significance of the report itself. The story is summarized in the first thirty-seven pages, and the industrial picture which it presents grows in detail as one reads on. An enormous amount of material had to be gathered, collated, and analyzed. It gives one pause to consider that data concerning the safety and the productive capacity of over one million workers was so inadequate that it had to be rejected.

A Notable Committee

A review of the report would be incomplete without specific mention of the notable committee who conducted the investigation under appointment of the American Engineering Council, and whose signatures appear on page 37 as follows: A. W. Berresford, chairman, L. P. Alford, vice-chairman, Lucian W. Chaney, L. W. Hatch, C. F. Loweth, Bradley Stoughton, Lewis DeBlois, J. P. Jackson, W. W. Nichols, and L. W. Wallace.

The report includes definite recommendations on the part of the Committee directed toward managerial methods for betterment of production and the safety of the worker.

Digest of the Report

Following the "Statement of the Problem" and the findings of the Committee is a "Digest of the Report." This is a more ample and detailed summary. This section is illustrated by 31 concise graphic charts. Some 250 graphic charts are used in the remainder of the book. These charts, together with the brief accompanying comments, make the significance of the investigation apparent without undue effort on the part of the reader.

A profound industrial change took place when, immediately after the war, the cost of labor and materials doubled with respect to the cost of capital. Executives and all others who have to deal with these three basic industrial factors were "robbed" of the familiar cost comparisons with similar work previously done. This condition called for more study, and more fundamental study on the part of industrial managers. More attention is being given today to basic costs and industrial trends than ever before in the history of this country. For continued prosperity it is of the greatest importance that all national agencies representing specialized knowledge and skill cooperate for the benefit of industry as a whole. With such cooperation, there is every reason to expect continued and increasing prosperity because we can grow fat on what may be saved from the present industrial waste.

Interesting Example of Valuable Cooperation

The report of the American Engineering Council on Safety and Production is an interesting example of the kind of cooperation which should be increasingly practiced. When the National Bureau of Casualty and Surety Underwriters found that the data coming to them showed an alarming increase in accidents, how simple and natural it was for them to refer this fact to the American Engineering Council. Through this body the engineering resources of the United States were brought to bear upon it. The result of this praiseworthy cooperation is one of the most valuable reports that the purposeful manager has yet received.

The relation between safety and efficiency (production), Mr. Whitney says—"is not a direct relationship at all, but arises out of the fact that both are the results of a third factor, namely, a purposeful, powerful, dynamic, and executive organization of the industry. An industry that is rightly conceived and organized will function properly, not in one respect, but in all respects. It will be efficient, not through any special quality, but because it is functioning as it was meant to function; it will be safe, not primarily because of special precautions, but because safety is a characteristic of an industry that is functioning properly."

A Study in Industrial Accidents

AN ANALYSIS has been made of disabling accidents which occurred in a year in a metal-working plant employing about 5000 men. Chief among the conclusions drawn are these: That the accident rate was much higher among foreign-born workers than among native born; that newly employed men had a lower rate than those of longer service; that the blame for 87 per cent of the accidents rested with the injured man; and that machines in motion were responsible for less than one-fourth as many accidents as were caused in the handling of material.—*The Iron Age*, June 7, 1928, pp. 1625–1626.

The Problem of Storage for Flood Control And for Power Development

Particulars Regarding Great Lakes and Large River Reservoir Systems, as Well as Irrigation And Flood-Prevention Reservoirs, From Which It Is Concluded That Generally Reservoirs for Combined Purposes Are Not Warranted

By DANIEL W. MEAD,[1] MADISON, WIS.

THE actual use of storage reservoirs will, the author believes, give the clearest idea of the feasibility of the combined use of storage for flood control and for power purposes. That reservoirs under favorable circumstances may be used successfully for both flood prevention and water powers is demonstrated by the regulation of the St. Marys, Niagara, and St. Lawrence Rivers by the Great Lakes System. While the regulation of these streams is not perfect, it is sufficiently complete so that no serious floods occur except from occasional ice jams, and the flow is sufficiently constant to permit a large and profitable use of the waters for navigation and water power.

The Great Lakes Reservoir System

The flow of the St. Lawrence at the outlet of Lake Ontario averages about 255,000 cu. ft. per sec., and the variation above and below that quantity seldom exceeds 30 per cent. While this is not perfect regulation, it approaches such condition sufficiently to prevent serious flood and to improve greatly the stream-flow for water-power purposes over what would obtain without regulation. The regulation of these rivers is the result of a storage area in the Great Lakes of about 95,600 square miles, or about one-third of the entire drainage area (Fig. 1). While the maximum variation in the water level of the Great Lakes during a considerable term of years is about four feet, the annual variation is about one foot and the annual storage is about 60,000,000 acre-feet. Such regulation on the Mississippi River drainage area would be both physically and financially impossible.

That similar complete regulations cannot be artificially produced on any but small streams, and then only under particularly favorable circumstances is almost self-evident. Any regulation attempted on the Mississippi drainage area must be so limited in extent that it must be practically confined to the particular purpose for which it is created, and can be of a little service to other ends.

The Upper Mississippi River Reservoir System

The system of reservoirs constructed on the Upper Mississippi drainage area in the State of Minnesota (Fig. 2) is believed to be the largest reservoir system that has been constructed on any river. This system consists of six reservoirs of a combined capacity of 93,500,000,000 cu. ft. or about 2,152,000 acre-feet. These reservoirs have a combined area of about 516 square miles, and control a drainage area of about 3800 square miles; they were constructed and are used primarily for navigation purposes, i.e., to increase the depth of the Mississippi River above Lake Pepin. These reservoirs have apparently fulfilled in a fairly satisfactory manner the function for which they were designed and have increased the navigable depth of the river at St. Paul by 15 to 18 in., with the exception perhaps on an average of about one year in ten. They were built when land and flowage rights were cheap, before the country was greatly developed. These reservoirs have had other incidental benefits (Fig. 3). Between Pokegama Falls and St. Paul the river has a fall of 482 feet, much of which has been developed for water power. Below the reservoir as the various tributaries join the main stream, the normal flow increases and the water from the reservoirs becomes a smaller proportion of the whole, and the interests of the water powers more nearly parallel the interests of navigation because, with the exception of the low-flow period of the winter, the reservoir waters are released when the normal flow of the river is low. These reservoirs are of undoubted benefit to those water powers, although not to the extent that they would be if manipulated for water-power purposes only.

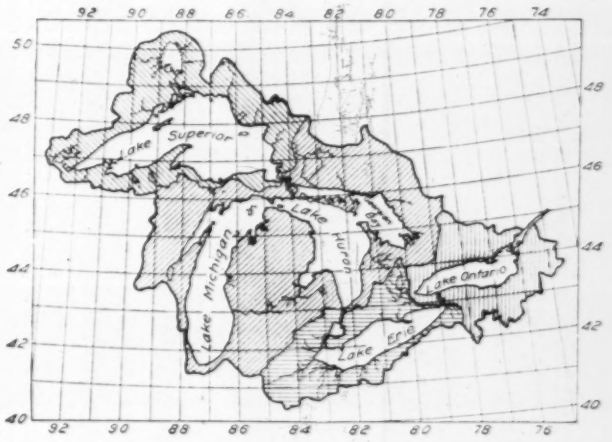

Fig. 1 Drainage Area of the Great Lakes

There has been almost continually a conflict of interests over the operation of these reservoirs. One power company demands a constant discharge for power purposes. The farmers whose lands adjoin the reservoirs demand an early lowering of the reservoirs so that they may obtain a hay crop from the overflowed lands, while navigation interests demand the retention of the storage until the low-water periods of summer. Incidentally the flood flows below the reservoirs are reduced, but this effect is less and less as the drainage area increases, and these reservoirs have no material effect on either the high or low water flow below Lake Pepin. The reservoir board has estimated that these reservoirs decreased the flood height of the Mississippi River at Cairo, Ill., during the floods of 1912 and 1927 by 0.2 in., the flood of 1922 by 0.33 in., and slightly increased the floods of 1913 and 1916, due to the fact that water was being discharged to assist navigation on the upper river.

The Wisconsin River Reservoir System

The Wisconsin River, the largest river in Wisconsin, has on its head waters (Fig. 4) nineteen reservoirs having a combined

[1] Consulting Engineer, Mead & Seastone. Mem. A.S.M.E.

Presented at the Midwest Power Conference, Chicago, Ill., February 14 to 17, 1928.

storage capacity of 9,067,000,000 cu. ft. or about 195,000 acre-feet during the winter season, but which on account of summer-resort conditions has to be reduced in summer by about one billion acre-feet. These reservoirs are maintained for power purposes only.

The difficulties of regulating the flow of rivers by reservoirs, for even that single purpose, is not commonly recognized. These reservoirs only partially control a drainage area of 2274 square miles above Tomahawk. Below the reservoired area are numerous water power plants among which may be mentioned the following, each with the drainage areas from which its waters are received:

Plant location	Drainage area, square miles	Unregulated area	Percentage unregulated
Merrill	2582	308	12
Wausau	3137	863	27
Wisconsin Rapids	5444	3220	59
Nekoosa	5677	3403	60
Kilbourn	7877	5603	72
Prairie du Sac	7987	5713	72
Total Wisconsin River area	12250	9976	81

FIG. 2 RESERVOIR SYSTEM AT HEAD WATERS OF MISSISSIPPI RIVER

Reservoirs	Capacity, Cu. Ft.
Leech Lake	32,400,000,000
Lake Winnibigoshish	42,200,000,000
Pokegama Falls	5,300,000,000
Pine River	7,600,000,000
Sandy River	3,100,000,000
Gull Lake	3,000,000,000

Each of the lower plants receives annually from the uncontrolled drainage area a proportion of flow (in cubic feet per second per square mile) equal to or slightly greater than that from the controlled area. That is to say, at Wisconsin Rapids and Nekoosa, fully 60 per cent of the water passing these plants in most years comes from areas having no reservoirs, while fully 75 per cent of the waters passing Kilbourn and Prairie du Sac are unmodified in their flow by reservoirs. The rains producing river flows are never equally distributed over the drainage area of a stream. It frequently occurs that when the water powers on the upper Wisconsin River have insufficient water for power purposes, and therefore water must be released from the reservoirs for their benefit, the lower powers have ample water for their purposes from the uncontrolled areas. In consequence of these conditions, the waters discharged from the reservoirs for the benefit of the upper water power frequently reach the lower powers when they already have an abundance of water. In such cases the reservoir waters are wasted over the dams with other surplus water that cannot be utilized. Careful calculations of the river flow at Kilbourn, Wis., for several different years show that about fifty per cent of the waters discharged from the reservoirs can-

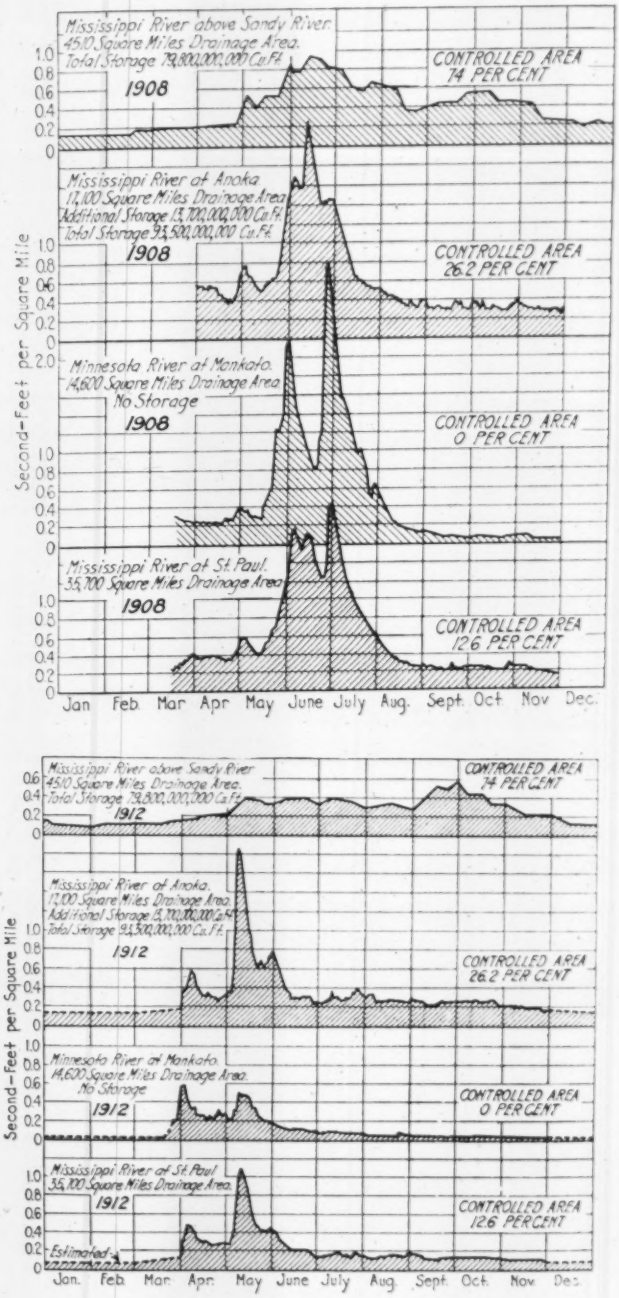
Mississippi River above Sandy River
4510 Square Miles Drainage Area.
Total Storage 79,800,000,000 Cu.Ft.
1908
CONTROLLED AREA 74 PER CENT
Mississippi River at Anoka
17,100 Square Miles Drainage Area
Additional Storage 13,700,000,000 Cu.Ft.
Total Storage 93,500,000,000 Cu.Ft.
1908
CONTROLLED AREA 26.2 PER CENT
Minnesota River at Mankato.
14,600 Square Miles Drainage Area
No Storage
1908
CONTROLLED AREA 0 PER CENT
Mississippi River at St. Paul.
35,700 Square Miles Drainage Area
1908
CONTROLLED AREA 12.6 PER CENT
Second-Feet per Square Mile
Jan Feb Mar Apr May June July Aug. Sept. Oct Nov Dec.
Mississippi River above Sandy River
4510 Square Miles Drainage Area.
Total Storage 79,800,000,000 Cu.Ft.
1912
CONTROLLED AREA 74 PER CENT
Mississippi River at Anoka
17,100 Square Miles Drainage Area
Additional Storage 13,700,000,000 Cu.Ft.
Total Storage 93,500,000,000 Cu.Ft.
1912
CONTROLLED AREA 26.2 PER CENT
Minnesota River at Mankato.
14,600 Square Miles Drainage Area.
No Storage
1912
CONTROLLED AREA 0 PER CENT
Mississippi River at St. Paul
35,700 Square Miles Drainage Area.
1912
Estimated
CONTROLLED AREA 12.6 PER CENT
Second-Feet per Square Mile
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

FIG. 3 COMPARATIVE HYDROGRAPHS AT SANDY RIVER, ANOKA, MANKATO, AND ST. PAUL

not be utilized by the plant of the Southern Wisconsin Power Company at that place.

This reservoir capacity can never be utilized to the greatest practicable amount until there is an interconnection of the power plants on the river, in which case, by equitable arrangement among the various interests involved, no water would be delivered from the reservoir as long as there was a sufficient flow in the

river to operate the lower plants. In that event these lower plants would operate to their capacity and furnish any deficiency of power needed by the upper plants. When the lower plants were short of water the reservoirs would then be opened, and the waters discharged would practically be utilized by all plants on the river. Such an arrangement would add many millions of kilowatt-hours of power to the combined annual output of the various plants on the Wisconsin River.

It is quite evident that if these reservoirs were regulated for flood-reduction purposes, their usefulness for water-power purposes would be seriously reduced. For flood reduction, they would have to be partially emptied whenever filled in order to catch prospective flood waters, and the waters so discharged would often be unavailable for any of the water-power plants on the river.

Even at the best, these reservoirs cannot be conceived to control more than 19 per cent of the drainage area of the entire Wisconsin River, and their actual control is very much less in extent on account of the actual distribution of the flood-producing rainfall. In October, 1911 (Fig. 5), occurred on the Wisconsin River the greatest flood on record. The center of the excessive rain crossed the state south of Wausau, and about 65 miles below the center of the reservoired area (Fig. 6). The maximum flood peaks occurred at Knowlton just below the path of the maximum rainfall, and progressed down the river at the rate of about 25 miles per day. The flood waters from Wausau and above did not add materially to the flood peaks at Knowlton, but arrived a few hours after the peak, and prolonged the flood wave. In consequence, the flood peak both above and below Knowlton was sharper and less prolonged. Above Kilbourn, the narrow channel of the Dells held back the water over the Lemonweir flats, and broadened the flood wave materially at Kilbourn and below. The reservoir system on the Wisconsin River undoubtedly held back to some extent the ordinary flow of the river which otherwise would have arrived in time to have augmented the flood at Merrill, Wausau, Knowlton, and the stations farther down the river, but could not have affected the flood height more than one or two inches on the upper river, and to a much less extent at Prairie du Sac and below. The flood waters from the uncontrolled area above Wausau did not reach Knowlton in time to have any effect on the peak of the flood, and the reservoired area had no effect on the flood peak except as it held back the pre-flood flow of the river.

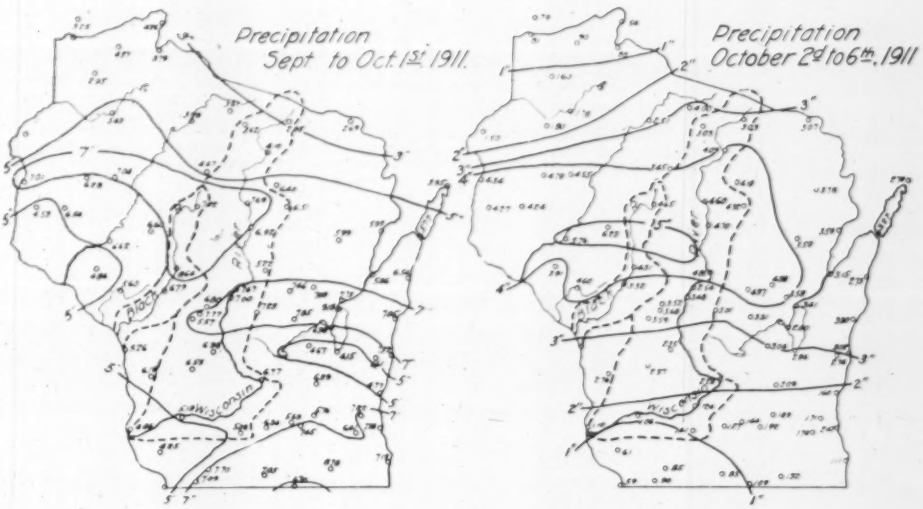

FIG. 5 WISCONSIN RAINFALL—FLOOD OF OCTOBER, 1911

FIG. 4 RESERVOIRS ON THE HEAD WATERS OF THE WISCONSIN RIVER
(Capacity: Winter, 9,067,000,000 cu. ft.; summer, 7,941,000,000 cu. ft.)

THE CHIPPEWA RIVER RESERVOIR SYSTEM

A system of reservoirs (Fig. 7) for power purposes, of a capacity of about 17,000,000,000 cu. ft., or 395,000 acre-feet, has been constructed on the headwaters of the Chippewa River system in Wisconsin. On the Flambeau River, the east main tributary of the Chippewa, a reservoir capacity of about 23,000 acre-feet has been in use for a number of years. Fig. 8 shows a hydrograph of the Flambeau near Butternut (upper, with 660 square miles drainage area), and at Big Falls (lower, with 1910 square miles drainage area). These hydrographs, although slightly modified by this reservoir, show remarkably similar discharge in crest flow (cubic feet per second per square mile). Fig. 9 shows similar hydrographs at the same station for the year 1926. In this year an additional reservoir with a capacity of about 135,000 acre-feet was placed in service about March 15. This new reservoir has a drainage area above it of 620 square miles which it only partially controls, as will be noted by the small flood peak in November at the river near Butternut. In general, however, for the most of the year the river at Butternut is well controlled as the area above the reservoir is 94 per cent of the area above Butternut. This control at Butternut is perhaps better shown by comparison with the hydrograph for the same year at Big Falls at which station the reservoir controlled drainage area is only about 32 per cent of the entire drainage area. While the hydrograph at Big Falls seems to indicate little control, the flood peaks in April, September, and November would undoubtedly have been much higher and, without the reservoir, the hydrograph at Butternut would have been similar to that at Big Falls except that the floods would have been even more accentuated.

IRRIGATION RESERVOIRS

Dr. Elwood Mead[2] has pointed out that there are located in the Mississippi drainage basin 1601 irrigation reservoirs with a total capacity of over 6,000,000 acre-feet, but that these reservoirs have a negligible effect on the Mississippi River floods as such floods arise elsewhere in the irrigated regions. He states:

> On the North Platte River former destructive floods have been practically eliminated by the construction by the U. S. Bureau of Reclamation of the Pathfinder and Guernsey Reservoirs. These two reservoirs provide 1,140,000 acre-feet out of the total storage on this stream of 1,800,000 acre-feet. On the South Platte, 338 reservoirs are in operation with a storage capacity of nearly 1,000,000 acre-feet. On the Arkansas, 367 reservoirs provide 1,155,000 acre-feet of storage, and the effect within the valleys of these streams, as well as other tributaries on which storage has been provided, has been highly beneficial.

The Reservoir Board has estimated the effect of eight of the larger reservoirs having a combined capacity of about 1,800,000 acre-feet as about $^1/_{16}$ in. at Cairo during the peak of the 1927 flood. From the best information available, it seems doubtful if the combined reservoir capacity on the upper Mississippi tributaries, amounting to about 8,745,000 acre feet, affected the flood height at Cairo during the flood crest of 1927 by as much as an inch.

THE MIAMI CONSERVANCY DISTRICT RESERVOIRS

These reservoirs, five in number, were constructed for the purpose of protecting the Great Miami River Valley from such floods as that of 1913 which caused a loss of almost 400 lives and of $100,000,000 in property. These reservoirs have a combined maximum capacity of about 841,000 acre-feet. They are constructed with fixed openings and are designed to hold back flood waters so that the capacity of the channels of the stream below them will not be exceeded. Floods which would pass off in two or three days are by this means reduced in magnitude but prolonged for perhaps eight or ten days. In consequence of these reservoirs, floods which would enter the Ohio with high intensity within three or four days after the fall of flood-producing rainfalls, are prolonged so that they may accentuate flood waves from the upper Ohio which pass down the river after the flood wave from the Miami would normally have passed down the stream. The Reservoir Board of the U. S. A. Engineers has estimated that these reservoirs as constructed, if they had been then in operation, would with respect to the Ohio River have decreased the flood of 1912; would have increased the floods of 1913 and 1922; and would not have affected heights of 1916 and 1927.

FIG. 7 RESERVOIRS AT HEAD WATERS OF CHIPPEWA RIVER

Chippewa, 10,000,000,000 cu. ft.
Flambeau, 5,900,000,000 cu. ft.
Rest Lake, 1,010,000,000 cu. ft.
Moose Lake, 390,000,000 cu. ft.

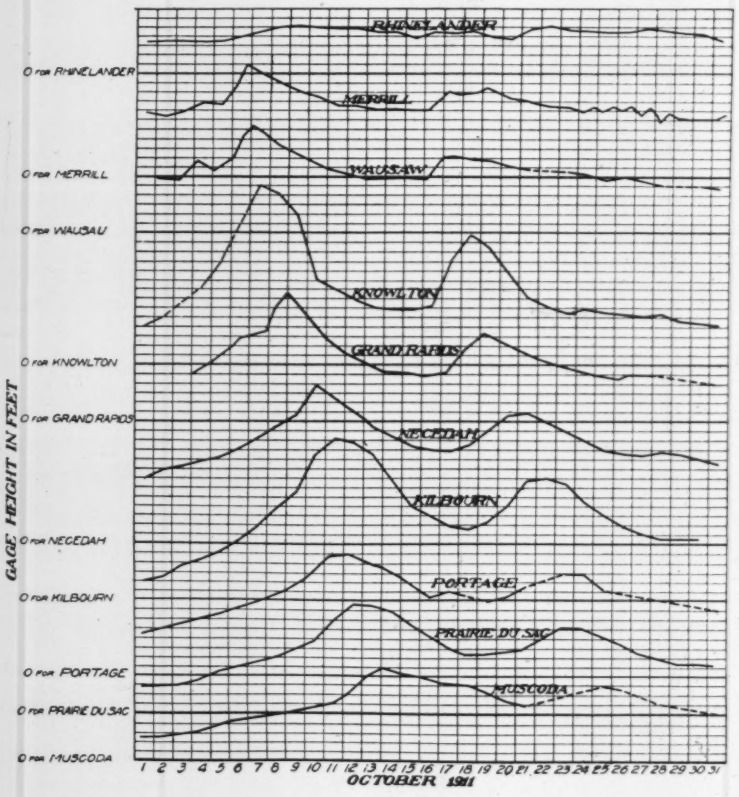

FIG. 6 ADVANCE OF FLOOD WAVE ON WISCONSIN RIVER, OCTOBER, 1911

It is quite apparent that reservoirs for navigation, irrigation, and water-power purposes may materially modify the floods on the stream immediately below them, when their area is a considerable percentage of the drainage area considered, but the effect grows smaller and smaller as the relative drainage area increases, and, in the case of the Mississippi River, with a total drainage area of 1,240,000 square miles, becomes so small as to be inappreciable. If such reservoirs were operated for the particular purpose of flood protection, their effect on the flood flow would be only slightly increased while their usefulness for the purposes for which they have been constructed would be very seriously affected and in certain cases almost entirely destroyed.

In general, flood-preventing reservoirs should be emptied after a flood as rapidly as the flow in the river below the reservoirs will permit, so that the reservoir will be able to receive further floods if they occur.

While floods are apt to occur at fairly definite dates, and often

[2] Proc. Am. Soc. C. E., Dec., 1927, p. 2607.

are not immediately followed by further floods, occasionally other floods do follow and there is real danger in allowing flood-prevention reservoirs to remain full in order to utilize the waters for any other purpose.

It will be recalled that in the flood of the lower Mississippi River in 1927, the main flood at Arkansas City was followed

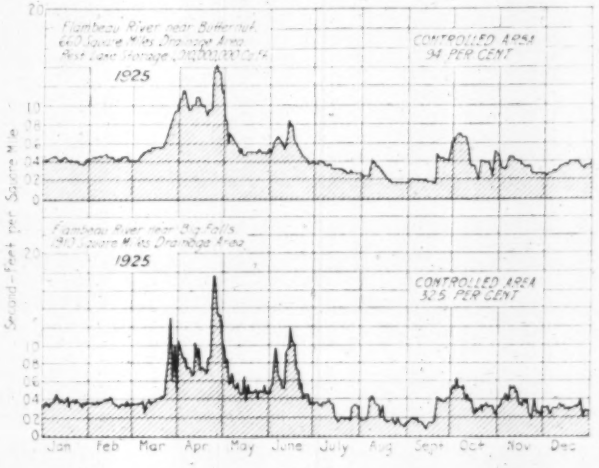

Fig. 8

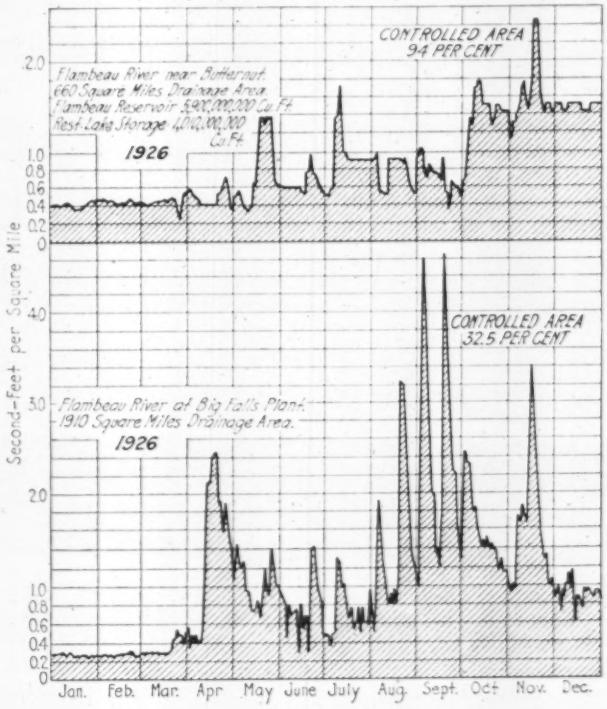
CONTROLLED AREA
9.4 PER CENT
Flambeau River near Butternut
660 Square Miles Drainage Area
Flambeau Reservoir 640,000,000 Cu Ft
Rest-Lake Storage 400,000,000 Cu Ft
1926
CONTROLLED AREA
32.5 PER CENT
Flambeau River at Big Falls Plant
1910 Square Miles Drainage Area
1926
Second-Feet per Square Mile
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Fig. 9

FIGS. 8 AND 9 COMPARATIVE HYDROGRAPHS OF FLAMBEAU RIVER NEAR BUTTERNUT AND BIG FALLS

by three or four additional floods. In the Mississippi River at Cairo, Ill., in 1922, there were two flood peaks of essentially the same intensity, one on March 25 being followed by the second on April 25.

RESERVOIRS FOR FLOOD PREVENTION

Reservoirs for flood prevention must be constructed within or below the area on which the flood-producing rains fall. In the case of the Mississippi River such rains rarely cover more than a third of the drainage area. On this account, reservoirs if generally distributed over the Mississippi drainage area would have to be three or more times the capacity needed for any particular flood.

If such reservoirs could be located adjacent to the lower river where they would be available for every flood a smaller capacity would be sufficient, and such reservoirs might be feasible as a partial relief for the lower Mississippi floods.

In general, the various uses of reservoirs are, to an extent at least, antagonistic, but in some cases may be utilized for more than one purpose.

Some of the irrigation reservoirs in California, while utilized primarily for irrigation purposes, are able while delivering water for irrigation to develop power which they sell to the various power companies of the state. This is possible on account of the fact that during the summer months when irrigation is necessary, the streams from which power is developed are usually at their minimum flow, and the power companies are short of hydroelectric power which some of the irrigation districts can supply in part.

The Elephant Butte Reclamation Reservoir on the Rio Grande was designed with a definite portion of its capacity (400,000 acre-feet) assigned to flood control. This reservoir is said to have more than paid its cost:

1 In the value of crops raised from irrigation, and

2 In the saving in flood losses above and below El Paso.

The Roosevelt Reservoir on the Salt River in Arizona and the American Falls Reservoir on the Snake River in Idaho have also materially affected the floods on those rivers.

Finally, the foregoing information leads to the following conclusions:

1 That approximately complete control of a river system such as is provided by the Great Lakes is of definite advantage to both flood prevention and water-power development, but that such control is practically impossible by artificial means on any large river system.

2 That with partial control on any large river system the combined use of reservoirs for flood protection and other purposes is so antagonistic as to be inexpedient.

3 That reservoirs for whatever purpose they may be constructed will have minor favorable effects for most other purposes in that they will tend to equalize the streamflow.

4 That in general, reservoirs should be built and operated for a single purpose when found financially advantageous for such purpose, and that with few exceptions the use of reservoirs for combined services is not warranted except when they can be so used as not to interfere with the purpose for which they were constructed.

Luminous Pressure Waves

PHOTOGRAPHY of the phenomena taking place when a cartridge of dynamite is detonated has shown the existence of luminous waves propagated at high speed in the air surrounding the explosive. It was at first thought by United States Bureau of Mines engineers conducting these experiments that these waves were merely reacting gases projected from the explosive, but further work in which the air around the stick has been replaced by hydrogen or carbon dioxide has made it seem probable that these are really pressure waves at such high temperatures that the gas actually radiates in the visible region of the spectrum. The work is part of a program of investigation by the Bureau of Mines of the sensitivity of explosives to detonation by influence.

The Economic Challenge of Industrial Germany

By EDWARD J. MEHREN,[1] NEW YORK, N. Y.

MY SUBJECT relates chiefly to some of the things that are happening at the present time in industrial Germany. Germany is making the progress, industrially, that you have heard about, and this is a matter of concern to American engineers, to American industrialists. You men have set as your task the saving of labor in industry by the application of machinery and power to the handling of materials. I presume no one would deny that in that branch of our industrial operations we are still using too little power and are still absorbing too large a part of our labor cost. If there is a portending challenge from the other side of the water in what Germany is doing, and I think there may be, though I shall give a necessary qualification to that later on, I believe it has a bearing upon the task you have set yourselves to do. If you can do your part, and it is a large part, in the rapid economical flow of material through the plant, then you will have done your share to offset the increasing efficiency of German industry, which necessarily must be met by us on this side of the water.

Before plunging into the subject, let me give you one point of view with reference to Germany that will help orient us as to the intensity with which the Germans are pursuing their efforts to increase their industrial efficiency.

It is an axiom of trade that two people can continue to trade together only if there is a mutual interchange of goods. That is axiomatic in foreign trade as well. One country cannot always continue to be the buyer; it must sell as well, and foreign trade, through the invisible items, if not through the visible ones, must eventually balance. Yet Germany's position is peculiar; she must have an unbalanced foreign trade, for a time at least. That is due to the large volume of reparations that she must pay, and also to the fact that she has been a very heavy borrower of foreign capital in recent years, and must repay what she has borrowed. These repayments can be made only in goods. There isn't a huge stock of gold in Germany that can be transferred outside her borders to make those payments. Germany therefore is under the peculiar necessity, peculiar from the economic standpoint, of being obliged to build up a heavy export balance. So far her balance is unfavorable; she takes in more than she sends out. Nevertheless—and this is one of the mainsprings of German industrial endeavor—she must build up an export balance if she is to meet the reparations debts and pay back her loans.

Of course there is also the very obvious desire on the part of the Germans to "come back," to recapture their place in the sun, to get into a sound and a decent economic condition that will afford livable conditions to her people. That is a mainspring which would be active were the other question not existent. But the addition of the other problem, the necessity of eventually building up an export trade, gives a dual urge to the efforts that Germany is making today.

These efforts are of peculiar interest to American engineers. The work of Taylor, of Gantt, of Emerson, of Henry Ford, of a dozen other men who have led industrial thought, industrial management, in this country, is being studied with avidity by the Germans today. They acknowledge us to be the leaders in the productive process; they would like to imitate us, and they are leaving no stone unturned to find out what we are doing. What they are doing does not in its essence differ from our American industrial practice. They are applying all the mechanisms of scientific management and of scientific organization of labor; they are working on a simplification of varieties, a standardization of materials, of parts, and of finished products.

Now all those things are not new to us. The important thing is that the Germans are following them with an intensity which promises that they may run ahead of us in the further development of those devices, and in their application. In their essence, however, they have not, so far as I have been able to discover, originated anything; they are rather imitating us.

Germany's Adoption of American Management Methods

As I said, the Germans are applying scientific management, simplification of varieties, standardization, and they include all of these things under the head of "rationalization." This is a term that they arrived at in their philosophical work, the application of the philosophical process to industry, but they have gone beyond us in that matter in that they haven't been content to let industry work out this problem by itself. The German acquired a habit long before the war of turning to his government for assistance far more than we have ever done, and he has turned to his government in this respect. He has turned to it not only that it might set up standardizing agencies, that it might work on simplification of variety and conduct research on various elements of scientific management, but he has gone so far as to point out that if the industries of Germany were to unite in a great consolidation program, very considerable industrial economies could be effected, and for that reason the German Government several years ago passed two laws reducing the taxes upon consolidations of industry. If they were, for example, to enter upon a new line, enter upon a new industry and buy a plant, they had to pay a rather high tax upon the property transfer involved, but if they consolidated two industries, their tax was only one-fourth the normal tax. That was done in order to encourage the consolidation of industry. Furthermore, if they refinanced their corporation and issued stock, they had to pay a very stiff stock-transfer tax. But if they issued stock in order to consolidate two, three, four, or five companies, the tax again was only about one-fourth or one-fifth of what it would be normally.

That runs quite contrary to our own governmental view of things. It is true that our Government doesn't obstruct the consolidation of industries, but nevertheless, with the Sherman Law and the Clayton Anti-Trust Law in the offing, it hardly encourages it.

Government Encouragement of Industrial Research

In Germany, however, there was distinct encouragement, and the reason for it was that the German Government was convinced by the industrial leaders that consolidations of industry would allow the specialization of certain plants and the closing down of uneconomic units. It would reduce overhead and selling costs, all of which would work toward economy in production. With reference to government encouragement of

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[1] Vice-President, McGraw-Hill Publishing Co.

Address at the First National Meeting of the A.S.M.E. Materials Handling Division, Philadelphia, Pa., April 23 and 24, 1928. Slightly abridged.

this program, there is another thing to be noted. The Germans have set up what they call the Trusteeship for Economic Research. This is a body whose function might be described as a combination of the functions of our Department of Commerce and the American Engineering Standards Committee. It was set up in order to survey all possible areas of waste reduction and all possible methods of reducing industrial costs. It surveys everything conceivable in the engineering and industrial line, the use of material, both raw and semi-finished. It studies industrial management methods, machine-tool development, office methods, personnel work—everything conceivable. Its function is to find out whether any one else is doing these things, and if it is discovered, for example, that no one is working upon a new method of making table ware, the government furnishes funds for a period of a year, or two years possibly, in order that a proper research upon the clays entering into pottery work may be undertaken. That research is financed on a very modest basis, the idea being that the government will convince the industry that the industry itself should carry it on, and instead of spending, say, $10,000 a year, that the industry will ultimately finance the research to the extent of $50,000 or $100,000. They haven't much money for it, but 2,300,000 marks, which is what they had last year, spread around in sums of 15,000 or 20,000 marks will stimulate a tremendous amount of research work, and that is exactly what they are doing. They try to discover possible means of reducing production costs, and then if they are not already covered, they put a research worker or a group of research workers on the job. In that way they hope to give assurance to German industry that there is no possible ground or place for economy in production that will be left unexplored.

That is the first great effort that the Germans are using in order to come back in an industrial way, to reduce costs in every possible direction. The second is a great intensification of the research work for which they were famous before the war. The German is particularly adapted to that sort of work. He is a student by nature, he is extremely patient, he will toil away at a minutia that tries our patience, and everywhere you go in Germany you find groups of research workers set up, chiefly in individual industries, but to some extent under the guidance of associations, pursuing not only the engineering of developmental research, with which we are most familiar, but having hosts of scientific workers as well. I visited one chemical plant where they had 300 men in the laboratories; 200 of them were engaged in developing products, and 100 were delving in the realms of pure chemistry, just to see what they could find. One-third of the men were engaged in pure scientific research with no definite objective and the other two-thirds upon particular-product research, and that is rather typical.

Now let me give you two instances of what has been done recently in Germany as a result of their research work. The Germans have made themselves completely independent of Chile saltpeter. They not only take their nitrogen supply from the air, but manufacture a surplus and export it. Therefore the imports relatively are reduced, and correspondingly, of course, the export balance automatically increased. Second, they have a surplus of nitrogen to export, and thereby they increase their export balance; and third, by having cheaper nitrogen available for the German farmer, they expect to increase the crop production and thus again reduce the amount that they have to buy in outside markets. In other words, by making all of their nitrogen and a surplus for export, they are attacking the export balance in three different ways, all three of them tending to increase it.

The other notable example of research work is one about which we have heard considerable, and that is the liquefaction of coal. It is the expectation in Germany that the liquefaction of coal will make it unnecessary eventually for her to import petroleum, and again it aids in building up that export trade balance which is so vitally needed. If they don't have to bring in any oil, it reduces their imports and therefore increases the export balance. The first large plant will go into service this year, and it is being built on the basis that they will be able to liquefy coal and thereby get their gasoline and lubricating oils at a lower cost than they can import foreign petroleums and refine them in Germany.

The New Attitude Between Employer and Employee In Germany

The third means by which they are trying to build up their commercial position is one to which I have never seen any reference in the American press, namely, the development of a new attitude between employer and employee in Germany. That new attitude springs from two points. The first is that the German employer has caught the idea that the salary earners and the wage earners do not merely take money out of your treasury, but that they are customers as well. Well-paid wage earners and salary earners are good customers, and good customers keep the factory wheels moving. For that reason the German manufacturer is intensely interested at the present time in the improvement of the position of the wage and the salary classes in Germany. We have awakened to that in the last few years as never before. We have realized that a prosperous public, a prosperous earning class, will make a prosperous industry. I don't mean to say the German manufacturer is increasing wages right and left. He is not. Obviously, he has to keep his wage bill in balance with the rest of the industrial situation of the country. As a matter of fact, last year two very large strikes were threatened and would have resulted in lockouts if the government had not intervened and insisted that the wages that were fixed by the government arbitrators be accepted by the employers. Nevertheless, the attitude toward the employee in Germany is very considerably softened, and I got it not only from the employer but from the representatives of the employees as well. There is a reciprocal attitude on the part of the employee. The German workman realizes that he can return to prosperity only if the country is prosperous, and that the country can be prosperous only if production can be increased or production costs brought down. For that reason the officers of the German Federation of Labor are going about the country, preaching to the local unions that they must cooperate with the employers in cost-reduction processes of all sorts. Further, they explain what they mean by these cost-reduction processes, and they are carrying on virtually employees' classes in scientific management, in simplification work, in standardization, and are showing the employee his part in that sort of thing. Particularly are they insisting that nothing shall be done to discourage the manufacturer putting in labor-saving machinery, and they tell the employee face to face, "Yes, you are going to suffer for a while; you may lose your job because a machine is put in which will allow one man to produce as much as four men did before, and three of you are going to be out of work for a time." But they insist that in the long run that employee will be better off when he is reabsorbed into another industry and the productive capacity per man is increased. If that isn't advancement in labor relationship, I don't know what is. And despite the fact that we have had extraordinary prosperity in this country, by and large that disposition has not been shown on the part of American labor, and I submit in that respect the Germans are somewhat ahead of us. I believe that augurs very well for the industrial rehabilitation of Germany. I believe it is going to make, too, for higher wages generally in Germany, a higher real wage—in other words, higher purchasing power for

the German people. The reason for that is that if these employees do work with the employer in reducing labor costs and installing labor-saving machinery and the other devices of scientific management, they are so strong that they will be able to demand a fair share of the fruits of that reconstruction work.

One thing I want to touch on, and that is that the Germans have a tremendous resource in the spirit of sacrifice and hard work that is prevalent among them today. I made it my business, wherever I met people in the ordinary walks of life, to ask them about their condition. The porters on the trains, the railroad conductors, the shopkeepers, the porters around the hotels, and so on. Wherever I could find a man who was apt to be up against it, or earning a small amount of money, I asked him how things were going. And the reply universally was, "Es geht." That means, "Well, you can get along. You can go."

I was in Germany in 1920 and again in 1924, on the same errand, trying to find out how conditions were there, and then when I asked that question there was nothing but discouragement; they were crushed with taxes, they weren't able to live on a decent standard, they couldn't have a holiday, their clothes showed the condition in which they were financially. Last year, no. "Es geht." "It goes." "You can get along." "Things are looking up, getting better." They have got enough food, at least. Clothes are beginning to appear decent. The cities look clean, and Germany is slowly creeping back to its normal condition. And its greatest asset, underlying all that is sure to push it farther along, is the spirit of self-sacrifice and hard work that is prevalent throughout the German people. There is a spirit, if you will, of hopefulness, mixed with only a reasonable amount of discontent, the same amount of discontent that every normal human being has of wanting to get ahead and improving his condition.

Now, what bearing has that got upon the problem which we are facing? It just has this bearing: that in neutral markets we are bound more and more to meet Germany as a severe competitor. I don't think it is going to come overnight, and it won't be here next year. Despite the things that I have said, Germany is under two very heavy handicaps, heavy taxation, and lack of capital. And until those two conditions are cured, Germany is going to be a cripple in international trade. But gradually she will overcome those two handicaps, and as she does, she will be a severe competitor of ours in foreign markets. We shall have to look to our laurels, but if we can keep up in our efforts at cost reduction as we have done in recent years, in our research work as we have been doing, we have nothing to fear from Germany.

While in Germany I had an interview with Dr. Duessberg, who is the head of the largest trust in Germany, the Dye Trust. And at the close of an hour or so of conversation with him on all manner of topics relating to the German industrial situation, I said, "What do you think of America?" He shook his finger and he said, "America can continue to lead the world for twenty years, if her young people will learn to work." Now, what he meant was that he thought it was going to be about twenty years before Germany's challenge to America could be successful. He qualified it by saying that they might catch up to us before that if our young people didn't learn to work.

Well, if we do, maybe we shall show Dr. Duessberg that he was mistaken and at the end of twenty years still be ahead of him, and keep ahead of him.

The Engineer's Place in Industrial Development

By WILLIAM D. ENNIS,[1] NEW YORK, N. Y.

BEGINNING with Cincinnati, in 1924, a number of cities have had modern industrial surveys. The subject has received a considerable amount of attention and public discussion. A great many things have been said about industrial surveys which are not so. A great many things have been called industrial surveys which are not industrial surveys. Some useful and important facts have been stated. Some obvious things, neither useful nor important, have been recited. Some things have been stated which are not true at all.

I am going to suggest what seem to be three rather outstanding facts.

The first fact: Transportation is the key to industrial location. Freight rates are the chief factor in determining where a plant should be. This is because the plant must pay freight on incoming material and on outgoing product. Freight rates are important also because they influence relative costs of living and therefore wage scales.

The estimation of freight-rate influence is a considerably larger matter than merely looking up tariffs. It is a larger matter than making statistical comparisons of rates. Rates constantly, though slowly, undergo modification. It is necessary to consider the basic rate structures and the way in which these are changing. Basic revisions are in process or are contemplated almost everywhere in the country. Industrial locations which are right today may be wrong tomorrow. This is not loose talk, but fact.

Practically speaking, our railroads are all built. The main channels of trade are determined. Confusing as is the freight-rate structure, there are some fundamental elements in it to which the industrialist must conform.

There is an old adage, "If a man builds his house in the woods and makes a better mouse trap or builds a better pair of shoes, the world will make a beaten track to his door." This may have been true when written. It is scarcely true today. The mouse trap and the shoes must be made where there *is* a beaten track.

Second fact: The steady movement of the center of manufactures of the United States proves that industrial localization varies and therefore that industrial opportunities exist. The amount of effort which Chambers of Commerce are applying, especially, perhaps, in the South and West, toward securing new industries proves what they think about this matter. The industries of the country do move; they are moving. They may well ask themselves, "Where shall we all be a hundred years from now?"

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Abstract of an address at the annual meeting of the Mohawk Valley Engineers' Club, Utica, N. Y., December 6, 1927, in connection with the completion of the Utica Industrial Survey.

WHY INDUSTRIES CHANGE THEIR LOCATIONS

They move because conditions change. Within the memory of plenty of men there has been a sweeping realignment of the iron and steel industries of this country. As we all know, textile manufacturing has redistributed itself geographically: perhaps pushed, on the one hand, by what is regarded as oppressive legislation in one section; and pulled, on the other hand, by a certain type of magnetic influence on the part of some cities.

A fundamental change is occurring in the make-up of the wage-earning groups in various industrial cities. Immigration restrictions will very soon begin to change the complexion of the population and consequently of the worker groups in our large cities. A typical northern industrial city has foreign-born whites constituting 25 per cent of its total population. If the present immigration laws continue, in thirty years its white-population composition will approximate that of a far-interior or southern city, say, like Atlanta.

We all understand that there is not very much transplanting of industry. Industry does not migrate that way. It migrates because of new developments, new industries like wood pulp and rayon; and because of the expansion of preferred plants to the disadvantage of other plants.

Excess facilities never have discouraged expansion. We never hesitate in this country to scrap an old tool when a better tool becomes available. An industrial location which has become unsuitable should be scrapped.

A third fact: The growth of a city can be directed. The corrective and inflative (so to speak) direction due to building-zone ordinances and to annexations of territory at once suggest themselves. There is good and bad direction. Giving bonuses to secure new industries is, I think, bad direction. It is another example of artificial stimulation. It takes industries to cities where they do not most naturally belong. When the bonus is used up the industry deprived of its artificial stimulation suffers. Theorists have been talking in recent years about the desirable size of city in which to live. This is an academic question, very largely. The desirable *type* of city is much more important: that can be controlled. I think of two industrial cities not far from New York. No one wants to live in either of them. Every one who possibly can, who has business in these cities, lives somewhere else. You have only to see them to recognize why. Then, in contrast, I think of cities like Springfield, Mass., and Dayton, Ohio, both strongly industrial cities, both splendid places in which to live. A city is made or marred according to the kinds of industry it cultivates and the ways in which these kinds are cultivated. These are determinable matters.

In some cases there are perfectly obvious good locations and equally obvious bad locations for specific industries. The old phrase about carrying coals to Newcastle illustrates what I mean. There are some necessarily local industries, like laundrying; but in general a city should not attempt to manufacture everything.

That sort of thing has been tried out. It was once the necessary policy, in pioneer days. The unit was not the city or even the ward or block; it was the family.

The rugged men who subdued this country were self-sufficient. They cleared the land and built their cabins. They clothed themselves, partly in skins or furs. They grew or gathered all that they needed in the way of food for themselves, their families, and their cattle. They provided their own fuel. The women folk spun and wove, made the candles, preserved foods, and even prepared their own medicines. There was no money and no need for any, although both whiskey and tobacco later became forms of currency.

As time went on and transportation developed, this state of affairs ceased and everybody was glad to get away from it. There came about what is sometimes called the division of labor, but might better be called the specialization of labor, or the division of services. Under this plan one man may do nothing but grow wheat, while another may do nothing but lay bricks. Each becomes skilled. Each would be useless at the other man's job. The sum total of production is increased. The whole country is better off.

So with cities. A city should accommodate those industries with which it can do best, and not any other kind. Local pride should not enter into the matter. Cities, unlike nations, do not need to be self-sufficient. It is good policy for a city to go outside and buy those things which can be made better and more cheaply outside. Let the city devote itself to its best specialties, and in this way it will have plenty of money to make necessary purchases.

The old-type Chamber of Commerce plan for securing new industries was much like advertising for a wife: you might get one, and you might wish you hadn't. The present plan for industrial stimulation gives primary attention to the matter of compatibility.

This is a long-range study. One of the troubles with it is that the man who is chiefly responsible for it cannot follow it through. I may plan, and something may happen to make my plan unworkable. We both run a risk under such conditions: we may be criticised; we may waste our time. The English statesman Burke once said:

> It generally argues some degree of natural impotence of mind, or some want of knowledge of the world, to hazard plans of government except from a seat of authority. . . . I have in general no very exalted opinion of the virtue of paper government, nor of any politics in which the plan is to be wholly separated from the execution.

Well, we recognize all this. The danger does exist. We are discounting it as much as possible by having a local organization which has participated at all points intimately and exhaustively in the work of the survey. That organization continues. And then, too, we are not altogether without a bump of caution. In connection with certain matters where conditions may change it will be found that recommendations are general rather than specific, that they have to do with methods and policies and not always with immediate action. Some people will criticise us for this. They will say we have not been sufficiently definite. That is why. We do not pretend to be supermen.

CHARACTERISTICS WHICH DISTINGUISH ENGINEERS

What are the distinctive things about engineers? How are they differentiated from ordinary folk? In the first place, I think engineers, generally speaking, have the habit of viewing things in an impersonal way. You cannot get very much excited over the elastic limit of a piece of steel. The engineer knows that if you mix concrete in the proportions 1:2:4 it will have rather definite properties, and if you use the proportions 1:2½:6 it will have other properties. The difference is not a matter of opinion, but of fact. Even in connection with human relationships, the engineer tries to be impersonal. There is an extremely personal way of handling men. An example of one extreme was in the old bucko mates of our sailing ships of 70 or 80 years ago. Those fellows knocked a man down when they wanted to make things clear to him. At the other extreme you have the altogether impractical sentimentality that Dickens pictured in the firm of Cheeryble Brothers in Nicholas Nickleby. The engineer's attitude seems to me to be a reasonable compromise, far removed from either of the attitudes suggested.

In the second place, the engineer's point of view is a quantitative point of view. He is a man who is always using a yardstick or a scales. He measures and weighs things. His analysis or diagnosis and his prescription are both quantitative. He

says, "Let this post be a 6 by 8;" the man who is not an engineer says, "Put in a good big post."

I hasten to add that engineering is not exact. Some of the engineer's calculations involving money costs may be a million dollars out of the way and yet entirely satisfactory. The engineer's calculations are very different from those of the accountant or financier. The accountant works to the nearest cent, regardless of magnitudes involved. The engineer rather aims at a known percentage of approximation. The unfortunate thing about this is that we do not always know that percentage, or the corresponding extent of our ignorance. When this is the case we have to play safe.

There are many kinds of engineers. I have heard of dietetic engineers and social engineers. The term has become popular. I am tempted to refer briefly to the very old story about the Welsh rabbit. It is not Welsh and it is not rabbit, but you all know the name of its principal constituent.

About 15 years ago the engineers of the country became class-conscious, to use a radical terminology. We began to read papers and hear addresses about the engineer's place in public life; which apparently was much the same as the place of snakes in Ireland: there wasn't any. Now we have an engineer in the President's Cabinet at Washington. Of course we are all proud of it. I sometimes think we are just a little transparent. Another member of the President's Cabinet, as I understand, is a physician. I have not heard of any of the medical societies passing resolutions or patting themselves on the back because of that fact. Still another member of the Cabinet is a banker, and the bankers of the country do not seem to be at all excited about it. I suppose there are some lawyers; it would be surprising if there were not.

If we wanted to push class-consciousness very far we might insist that the engineer in Gopher Prairie should be represented on the City Council, the Chamber of Commerce, the City Plan Commission, the Rotary Club, and so on ad infinitum. This is the bloc idea. May I suggest that sometimes it is a block*head* idea? I do not believe that to be the plan under which engineers exercise maximum usefulness.

I hasten to add that cities sometimes expect or accept unreasonable amounts of free engineering service. I doubt the wisdom of this. If a professional man is asked to express his judgment in the public interest he may very properly contribute that judgment without compensation. If he is asked to do a large amount of detailed work, the request is rather unreasonable and the effect is apt to be that nothing happens. When such requests are made the proper reaction would be for the local or national professional organization to designate its best-qualified man and suggest to the city authorities that they retain that man to do the job.

It is perfectly fair for us as engineers to do what men in other professions would do under like conditions. Our medical brethren are supposed to prescribe for the sick poor without thought of compensation; but they even things up by asking $10,000, perhaps, to remove a millionaire's appendix. A lawyer will under certain circumstances give his judgment on a legal problem involving his home public without compensation, but if the matter is at all uncertain he will be very cautious, and if it requires research and inquiry he expects to be paid.

THE FIELD OF THE ENGINEER

A true conception of engineering is not obtained by directing attention at the 136,000-odd technical engineers, so-called, in the 1920 census, out of nearly 42,000,000 persons usefully occupied. To approximate a correct notion of the field of the engineer, we must consider our manufacturing and mechanic industries, employing nearly 13,000,000 persons and producing goods worth about $65,000,000,000 this year. To these we must add the activities of transportation and transmission, employing over 3,000,000 persons and something like $35,000,000,000 worth of equipment in 1920. These figures represent the field and subject-matter of engineering.

The field of the engineer is the industrial field. It is the broadest and most important field of activity, materialistically speaking, in these United States. Many engineers do not view it in its due proportions. If I were to ask some one to name the chief group of industrial activities in this country, I suppose some would say iron and steel, and others would say motor vehicles. Motor vehicles do not constitute a group, but only a single industry in the group "transportation equipment." There is a group of industries, the food-preparation group, which showed in 1925 nearly twice the value of product of the whole transportation-equipment group and over 50 per cent more product than the iron and steel group. Yet I venture to say that the average engineering-college graduate never heard in his school days anything about such an immense and important industry as, for example, slaughtering and meat packing. This involves conveying machinery, process steam, and refrigeration, to mention only three important engineering branches.

Still more notably, we are not dealing with the matter of training workers for these various industries in any broad or comprehensive way. As I have stated, there are nearly 13,000,000 persons in this country engaged in the manufacturing and mechanic industries. The total number of apprentices in 1920 in the building and hand trades was under 74,000. Put it another way: counting only the blacksmiths, boilermakers, and machinists, this country in 1920 had virtually 1,100,000 skilled shop workers. There were practically 1,500,000 of masons, carpenters, painters, and plumbers. Corresponding with these 2,500,000 skilled workers, the proportion of apprentices, if we count all apprentices, which is erring seriously, is about 1 in 35.

There are men who do not agree with me that we need give a great deal more attention to the training of skilled workers. On the basis of figures like these, I suggest that we are taking a chance if we don't do it. Those who disagree with me may possibly be right and I may be wrong, but at any rate what I am advocating is safe, and what they are advocating is doubtful.

There are plenty of examples of professional men making large sacrifices for the public benefit. The most impressive case I know of was that of Sir Isaac Newton, whose bicentenary we have just been celebrating. There is a unique thing about Newton. Almost any one, and especially almost any engineer, would rank him easily first among the men of physical science in all ages. It is not so easy to pick out and agree upon a first man in other fields: in music, painting, architecture, military leadership, or other branches of activity; but it is quite certain that in physical science Newton would receive at least a majority vote. When this man was in late middle-age he was given a sinecure appointment in the royal mint. The thing was meant as a compliment more than anything else, but Newton found the coinage of the realm in bad shape. It needed standardization with respect to composition and dimensions of coins. He became interested, and before long was advanced to be keeper or master of the "King's mint." Now this is the remarkable thing. Writing while holding this office, he complained bitterly about the multitude of visitors who came to talk with him about "all manner of scientific things" while he was occupied with the royal business. This was impersonality carried to the *n*th degree.

Every man is a "debtor to his profession." We owe it to the whole body of engineers to face public responsibility soberly, and to give it a reasonable share of our time, and the best of our judgment all the time.

The Research Institute for Hydraulic and Hydroelectric Structures

An Account of the Plans and Activities of the "Forschungsinstitut für Wasserbau und Wasserkraft," with a Description of the Experimental Field of This German Institution And a Summary of Its Technical Accomplishments

By BLAKE R. VANLEER,[1] BERKELEY, CALIF.

THE Research Institute for Hydraulic and Hydroelectric Structures, known in Germany as the "Forschungsinstitut für Wasserbau und Wasserkraft" and which will hereafter be referred to as the "Forschungsinstitut," is unique, in that it is at present the only organization of its kind in the world devoting its attention exclusively to researches in hydraulics and hydroelectric structures. It was first conceived in 1924 by Dr. von Harnack, president of the Kaiser Wilhelm Gesellschaft, and Dr. Oskar von Miller, world-renowned engineer and scientist and founder of the Deutscher Museum. A group of interested and eminent engineers were assembled and the plans for the institution were launched in October, 1924. More than a year was thus spent in raising funds and making plans, and it was not until April, 1926, that the Forschungsinstitut was actually founded.

FIG. 1 AIRPLANE VIEW OF ISAR-WALCHENSEE CANAL BETWEEN STAUSEE AND WALLGAU

PURPOSES OF THE FORSCHUNGSINSTITUT

There are perhaps 150 hydraulic laboratories in the world today, about 60 of which are located in the United States. Most all of the contributions to the scientific literature on hydraulics have come from those engaged in work in the laboratories of our technical universities; but most of these researches have been conducted on a small scale, frequently upon models, and while the basic fundamental laws of dimensional similarity have been known and used for some time, and while they have worked very well for approximations, the time has arrived when we must have more accurate information, when a variation of 2 or 3 per cent is no longer tolerable. We must know accurately when we test a model of a hydraulic structure what we may expect from the original when it is built and tested in actual field service. The Forschungsinstitut proposes to do this. It proposes to be the connecting link between the scientific laboratory studies upon models and the actual original structures in field service. Further, it proposes to carefully train young men in the art and skill of making hydraulic measurements; and to carefully compare and check the various methods proposed for measuring large quantities of water in the field.

The Forschungsinstitut is under the direction of Dr. Ing. Otto Kirschmer, trained at the Technische Hochschule of Munich, for some time with the famous engineer and inventor, Lawazeck, later an engineer with the well-known manufacturer of hydraulic turbines, J. M. Voith of Heidenheim, and for three years assistant to Prof. Dr. Ing. D. Thoma, of the Hydraulic Institut of the Technische Hochschule of Munich. His staff consists of a secretary and from four to eight assistants.

The construction costs of the original plans of the Forschungsinstitut called for an expenditure of $360,000. The plans included a meteorological station; an office building and living quarters for those engaged in the field experimental work; and an experimental station in which experiments on high-pressure hydraulic machinery, and low-pressure experiments such as cavitation tests, etc., would be conducted.

LOCATION OF EXPERIMENTAL STATION AND FIELD

Great care was exercised in selecting the site for the researches, and probably no more ideal place could be found than that shown in Figs. 1 and 2. Here one finds in the heart of the Alps not only a most picturesque setting, but all of the natural physical and geographical phenomena with which a hydraulic engineer is concerned. First there is a large storage basin known as the "Stausee," where may be studied the interesting but frequently expensive phenomena of river sediment. Here the Isar river brings yearly tons of gravel and sediment, in fact about 100,000 cu. m. per year. The Stausee is approximately 1200 m. in length and a long tongue of gravel deposit, which is about 1.2 m. high, is moving forward each year at the rate of almost 100 m. It must not be permitted to move forward to the point where it will block and interfere with the intake to the canal. There are many interesting problems which may be studied here, but

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the most obvious and most valuable one should be that of finding the hydraulic structures necessary to make this river deposit its sediment where it is cheapest to remove.

From the Stausee the water flows through a trapezoidal canal 2.3 m. wide at the bottom, 11.42 m. wide at the top, and having a depth of 3.65 m. The slope of the sides is 4:5 and the maximum height to which the water is permitted to rise is 3.30 m., at which time the canal is carrying approximately 25 cu. m. per sec. (882

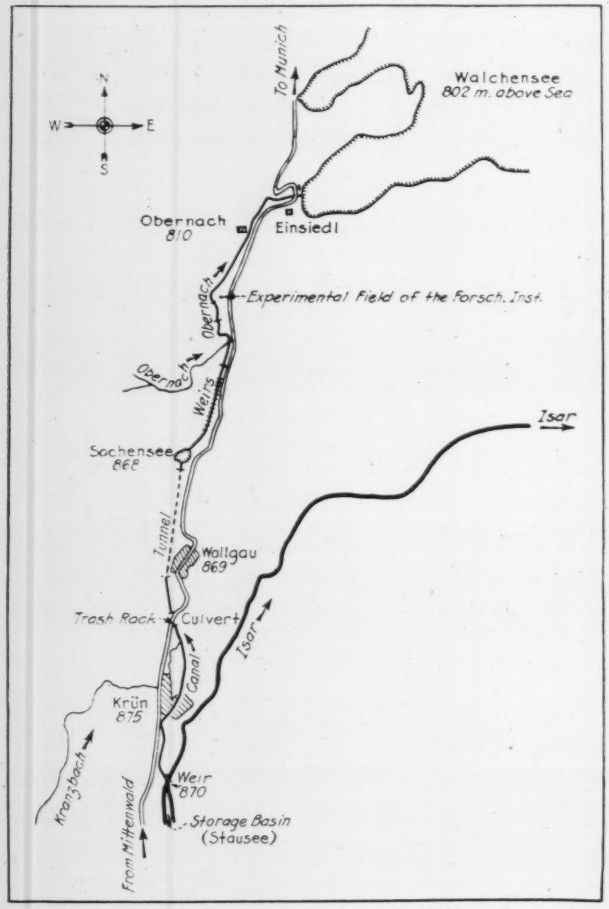

FIG. 2 MAP OF THE ISAR-WALCHENSEE CANAL, SCALE 1:100,000

cu. ft. per sec.). The slope of this canal is 0.3 per cent. Fig. 3 shows this canal at the village of Grun between the Stausee and the village of Wallgau, where experiments are conducted to dermine the loss in canal bends.

The water next flows through a straight stretch of canal 350 m. in length, where the current-meter gaging station is located (Fig. 4). The experiments were carried on and their results will be discussed later. The canal water next passes through trash racks and a culvert shown in Fig. 5, and after a short run the water is conducted under a small mountain by means of a tunnel, the entrance to which is shown in Fig. 6. This tunnel affords an excellent opportunity for many studies of losses at entrance and exit as well as friction losses.

This tunnel delivers the water to a small storage pond known as the Sachensee. Here another interesting phenomenon is being studied. The flowing stream of water, instead of losing its velocity and spreading out over the entire lake, as it is generally supposed to do, cuts a definite and clearly defined channel almost through the center of the lake. This is due to the fact that the lake is too shallow.

From the Sachensee the water passes through a canal over several weirs such as are shown in Fig. 7. This part of the canal is about 2 km. in length and is known as the Obernach Canal. It must be borne in mind that all of the works above described are part of the Walchensee hydroelectric development which is one of the largest in Germany, and while the Forschungsinstitut is permitted to make measurements and study these structures, it has no control over them, must use within certain limits the quantity of water which is available, and is permitted to make no alterations in permanent structures. The Obernach Canal leads to the experimental field shown in Fig. 8 which has been chosen for the site of the Hydraulic Experimental Station. Here the Forschungsinstitut has complete control of the property and may make such experimental changes as it deems necessary, with the one limitation that it must return to the channel the same amount of water it takes out.

As one looks at these weirs along the Obernach Canal he naturally wonders why this steady, almost constant supply of power is not put to use. The answer is, that this was contemplated and plans made for it, but Germany's economic condition, as well as the increasing cheapness of power generated from coal, has made the completion of the other power project conceived in conjunction with the Walchensee power plant at present economically unsound if not impossible. Hence, in response to the demand from nature lovers these beautiful weirs and waterfalls have been left in a state even more beautiful than nature had originally provided.

THE OBERNACH EXPERIMENTAL FIELD

Many different plans were prepared for the experimental

FIG. 3 POINT ON ISAR-WALCHENSEE CANAL BETWEEN STAUSEE AND WALLGAU WHERE EXPERIMENTS TO DETERMINE LOSSES IN CANAL BENDS ARE MADE

field at Obernach, and some of Germany's best hydraulic engineers have criticized the final ones shown in Fig. 8. Here along the main highway connecting Mittenwald, Walchensee, and Munich, over a distance of 800 m. in length, the following structures are to be started this summer: intake structures, including overflow spillway, a distribution basin, a large earth channel for studying sedimentation and bank erosion, a concrete canal for studying water-measurement methods (each of these canals

carry from 3 to 4 cu. m. per sec.), and a large calibrated volumetric measuring tank containing approximately 2500 cu. m. The large measuring canal capable of carrying 8 cu. m. per sec. shown in Fig. 8 will be built later.

Some such experimental station or field laboratory such as that shown in Fig. 8 is absolutely essential, because although there are available as described above many places which may be used to make studies, it is not possible to regulate or change any of the variables connected with them; hence one may have to wait days, weeks, or months for a duplication of a certain quantity desired, yet in an experimental field it may be duplicated as often as desired. Some of the problems to receive immediate investigation here in full-scale tests are:

1 A comparison of the different methods of measuring water in open channels with volumetric measurements.

2 An investigation of the movement of sediment, using the actual rock and gravel found in the river.

3 A study of the erosion effects of the water in channels with

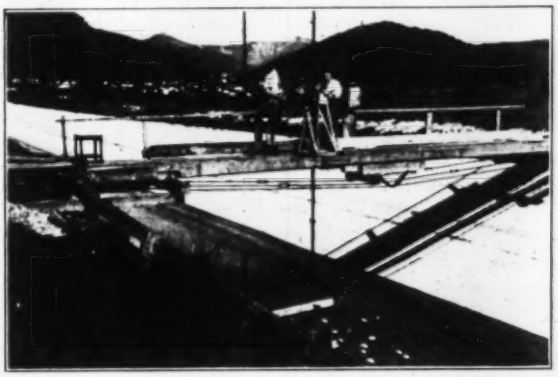

FIG. 4 CURRENT-METER GAGING STATION ON ISAR-WALCHENSEE CANAL

FIG. 5 TRASH RACKS AT ENTRANCE TO CULVERT UNDER ROAD NEAR WALLGAU

shifting beds, and in connection therewith an investigation of the effect of built-in structures.

4 Studies of the erosion effects produced by weirs and spillways in comparison to that shown by small-scale models.

SUMMARY OF TECHNICAL ACCOMPLISHMENTS

1 The Forschungsinstitut has prepared plans and drawings of buildings, channels, and experimental stations for the purpose of conducting researches in accordance with the purposes outlined above.

2 It has conducted experiments to find the discharge coefficients and the downstream erosion on overflow spillways and wiers with rounded crests on the scales 1:50; 1:25; and 1:1. The results of these experiments[2] are of great importance because they represent one of the few published accounts of the relation between model studies and the actual full-scale structure.

FIG. 6 ENTRANCE TO TUNNEL THROUGH MOUNTAIN NEAR WALLGAU

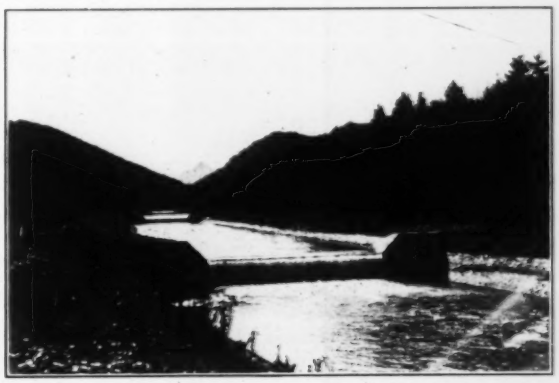

FIG. 7 WEIRS ON OBERNACH CANAL

One finds in this report of these tests actual scientifically determined quantitative values.

The chief results may be stated briefly as follows:

a The quantities and discharge coefficients obtained from the model tests on the scales 1:50 and 1:25 checked the results obtained from tests on the full-scale structure in the field quite accurately, and close enough for all demands of professional practice.

b The location and extent of the downstream erosion on the 1:50 scale model did not check that found with the full-scale structure. However, the model showed much greater erosion than that actually found, and also indicated the greatest depth—which is the important thing—to be much nearer the apron of the spillway than was actually found to be the case in the tests upon the full-size structure.

c The model tests showed that the discharge coefficients varied

[2] Mitteilungen, Heft 1, Forschungsinstitut für Wasserbau und Wasserkraft e. V., Munchen, Verlag von R. Oldenbourg, Munchen, 1928.

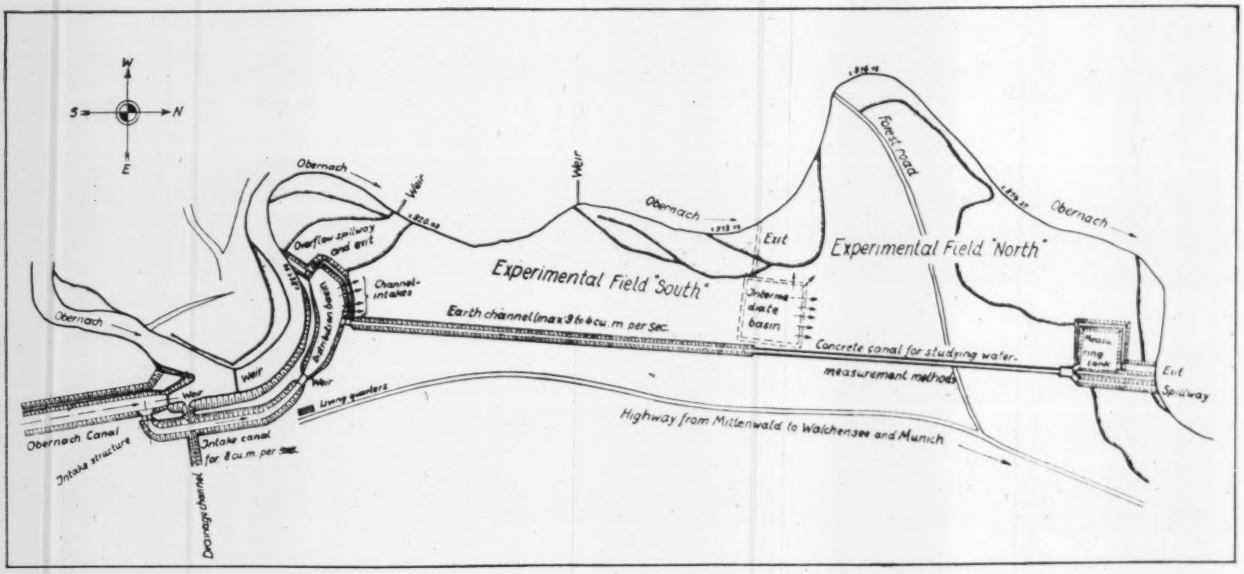

FIG. 8 MAP OF EXPERIMENTAL STATION AND FIELD OF THE FORSCHUNGSINSTITUT, SCALE 1:6000

for the same conditions of flow over a range of 6 per cent, and if this same variation occurs in the full-size structures the accuracy of the quantity and coefficient agreement is most remarkable.

3 A definite and accurate procedure in making current-meter measurements has been established, and although means are not yet available for determining accurately the standard quantity of water for comparison with the current-meter method, if the mean of all measurements made is assumed to be correct, the maximum error in the use of current meters is 0.4 per cent and the mean error is 0.2 per cent.

This article does not present a full and complete account of the plans and activities of the Forschungsinstitut, but it is hoped that it has given the reader some idea of the nature, scope, and future possibilities of this hydraulic research institution. Considering its brief life, its limited financial resources, and the numerous difficulties it has had to face, the Forschungsinstitut has accomplished an exceedingly large amount of work, and all who have an interest in scientific research and especially hydraulic research will cherish the hope that the institution will continue to find the financial support necessary to carry on its productive researches.

Motor-Truck Competition With Railroads in Germany

THIS competition appears to be particularly active in the Ruhr district, Silesia, and Sarre, where towns are very close together, the distances which the goods have to be carried are comparatively short, and hence the use of motor trucks is exceptionally attractive. The railroad rates for freight carriage for short distances as generally constituted in Germany are higher than the cost of transportation by motor truck, and furthermore the cost of carrying the goods to and from the railroad must be added (except, of course, in the case of plants having direct car service at both ends).

A careful investigation of costs of transportation has shown that up to a distance of 60 km. (37.28 miles) it costs more to haul goods by rail than by motor truck. Hence competition by general lowering of freight rates within those distances would not be to the advantage of the railroads because they would be carrying goods at a loss. The railroads have therefore worked out a scheme which permits them to compete with motor trucks for short-distance haulage and yet not lose revenue in non-competing fields. This has been done since the beginning of last year by introducing a number of special rates called "K" rates, which brought back a good deal of business to the railroads previously lost to motor trucks. These rates are based in the first place on the user's supplying not less than a given tonnage, and are applied for distances below 50 km. (31 miles) and to all classes of materials. Moreover, the German railroads are carefully studying the rates charged for the various auxiliary services, as well as the employment of motor-driven cars and light trains, primarily with a view to less-than-carload transport.

The State Railway Company at the beginning of last year organized a committee for examining from a general point of view the attitude which the railroad company operating under the Dawes plan (comprising practically all the German railroads) should take toward automobile lines. This committee estimated that at the present time the competition of automobiles causes the railroad company a loss of receipts of approximately 250,000,000 marks a year, of which 150,000,000 are for freight traffic and 100,000,000 for passenger traffic, and that this loss of income will grow with an increase in the number of automobiles. The committee has come to the conclusion that the measures which the company has taken or can take by way of rates are not sufficiently effective to meet the competition of motor traffic, and believes that the only way in which this situation can be handled is for the railroad company to place itself in a position where it can send the traffic either by rail or by road at the maximum economic efficiency. Since, however, the railroad company has not the equipment to organize road transport, the committee is of the opinion that it should establish a closer cooperation with the automobile transportation companies, and certain steps are actually being taken in this direction. (Part of an extensive article entitled, "German Railroads During the Third Year of Operation Under the Dawes Plan." *Revue Générale des Chemins de Fer*, vol. 47, no. 4, Apr., 1928, pp. 276–300.)

The Design and Supply of Naval Aircraft

By EDWARD P. WARNER,[1] ASSISTANT SECRETARY OF THE NAVY FOR AERONAUTICS

The stages in the development and production of an airplane are listed by the author as: (1) The formulation of the problem; (2) the determination of the general characteristics of an airplane to do the work; (3) the general layout of the structure; (4) the detailed design; (5) experimental construction and trial; (6) intermediate service tests; (7) regular production; and (8) mass production for emergency requirements. He then respectively discusses the shifting of the burden of responsibility from the governmental service to the private contractor, and vice versa; the most satisfactory mode of experimental aircraft procurement; the need for carrying forward experimental development with increased vigor; tests under service conditions; the necessity of keeping wartime requirements in view when planning a procurement program; the undesirability of distinct industrial and military aircraft industries growing up side by side; and the sympathetic relation and cooperation of the Government with the airplane industry as a whole.

A LOGICAL consideration of the problems of design and procurement of aircraft, for whatever purpose they may be intended, breaks itself up logically into several headings, corresponding to more or less accurately delineated chronological divisions of a process. Before airplanes can be procured in quantity, the types must have survived trial in the crucible of small-scale operation. Before the first machines have been built, there must have been a complete design. Before the design could be made it was, and is in every case, necessary that there should have been set forth a specification of the composite of qualities rated as desirable to be reconciled and realized by the finished fabric.

To leave the process of subdivision with so sweeping a discussion on lines so broad would be an unduly cavalier treatment. The preparation of a design is not one step but several, and the same is true of the production of the finished machine. It is convenient, in seeking for an itemization of processes at once clear and reasonable, to introduce additional points of transition corresponding to the definition of additional stages in the evolution and entry into full usefulness of the finished product. Such stages clearly identify themselves to the number of eight, and of that number one-half precede, the remaining half accompany or follow, the actual working of material in the shop for the construction of an actual airplane.

Stages in Development and Production

Speaking still in terms of chronological sequence, and sacrificing completeness of definition to brevity of nomenclature in a preliminary listing, the development proceeds through: (1) The formulation of the problem; (2) the determination of the general characteristics of an airplane to do the work; (3) the general layout of the structure; (4) the detailed design; (5) experimental construction and trial; (6) intermediate service tests; (7) regular production; and (8) mass production for emergency requirements.

The order of execution of the several stages is substantially invariable, but the cycle must none the less be regarded as quasi-reversible in a certain sense. The later stages may never precede the earlier ones, but they do react upon them, and the detail of design, to choose an outstanding example, is determined not only by the general nature of the problems to be met and by the characteristics of the layout and installation already adopted, but also by the facility of construction, either in single units, in small lots, or in vastly multiplied quantities. All features interact, and when dealing with almost any one of the eight, it is necessary to remain subconsciously attentive to all of the other seven.

Such interrelationships should be borne in mind as a guide post in proceeding to a detailed and individual examination of the several sub-headings of the evolutionary process. Another connecting link among them, also deserving to be the subject of particular attention at this part of the discussion, is the gradual transfer back and forth between the governmental service and the private constructor in industry of the burden of responsibility for various parts of the work. From the point of view of a general study of the design and procurement of airplanes for the Navy, the important question is not how, but where and by whom the several technical activities are to be carried on. If a particular piece of work is to be done within the service as a matter of ordinary routine, the technicians there employed may be relied upon to find means of doing it. If the same burden is turned over to the industry, the engineers in private employment in turn may be expected to arise to their responsibility; but in each stage from the germination of the concept of a new type to the completion and delivery of the last machine ever to be built from the design resulting from that concept, there must be a clear allocation of function between the user and the builder, between the potential purchaser and the would-be purveyor.

Allocation of Responsibility for Carrying Out Program

1 Concerning the distribution of responsibility for the outline of the conditions to be met, there is no room for difference of opinion. Only the user of a machine can know what he wants it to do, and in the case of airplanes for the naval service only those who live with the machines and keep them going, and plan for their incorporation in the tactical and strategical programs of naval operations as a whole, both now and as those plans are likely to develop in the future, are in a position to formulate a concrete statement of the characteristics which airplanes must have to be a useful part of the naval organization. The first stage is for the Navy Department, speaking in the light of service experience and of anticipated trends of development in the employment of naval aviation, either to write down or offer in discussion with representatives of the industry the tentative specifications, or performance, of accommodation, of flying qualities needed to render the forthcoming airplane an advance over anything at the moment existing.

2 The decision upon the general character and type and form of the airplane which will meet the requirements so laid down should be made primarily in the industry, although it is not practicable to concentrate the making of all such decisions in any one quarter. There may be occasion when specified needs in structural strength, in range of vision or fire, in seaworthiness or in some other feature, substantially prescribe the general character of the airplane to be designed. There may be, and there frequently are, instances in which the lessons of naval operating experience can only be expressed in a reasonably full manner through the preparation of sample designs by those who have had the experience. It is a good general rule, however, that the would-be contractor should be left the widest possible range of choice and that he should be given only instructions about the ends that he is to obtain, selecting his own means of attaining them, subject to the obvious desirability of encouraging occasional

[1] Washington, D. C. Assoc-Mem. A.S.M.E.

Presented at a meeting of the Washington Section of the A.S.M.E. Washington, D. C., March 3, 1927.

new lines of departure to avoid the risk of overstandardization and descent into a rut, and to the corresponding desirability, when several new machines are being obtained from as many sources but all intended for the same function, of having them as markedly different as possible in their form. It makes no inherent difference to the Navy Department whether the machine that makes good and that promises the largest future return is a monoplane or a triplane, whether it has two engines or six, whether it is covered with wood, fabric, or metal. The measurement of performance, using that term in the broadest sense to include all factors which influence service utility, should be and is the final arbiter of the destinies of a new design and of the response to the overtures of those who tender it.

3 The third stage falls in with the second. It is again the function of the contractor to make the layout, and the initial concern of the Government confines itself in general to examination and comparatively informal comment and criticism.

At about the point now reached in the development of a new airplane, there arises a new question. Discussion of the distribution of activity between the Navy and the private industry assumes a bifurcated form, relating itself on the one hand, as before, to the decision on where the work shall actually be done, and on the other to the assumption of financial responsibility. A constructor may build at his own risk with the hope of selling the finished product. The Navy may build in its own plant and with its own personnel. Thirdly, the work may be done in a private factory but under Government contract from the beginning and at Government expense. It is between the first and third of those alternatives that the decision has to be made when the preliminary general layout stands finished.

In no case would it be expected that a contract would be placed for the building of an airplane without having at least a set of assembly drawings of the proposed machine before the purchaser as a guide. In no case, on the other hand, would a manufacturer be expected to take a chance on the building at his own expense of more than one machine for which there might or might not prove to be a demand. Leaving out of consideration, then, the case in which the whole development of a design and its production are in the hands of the naval organization, a case exceedingly rare and represented in the last five years only by four or five designs, mostly large flying boats, and confining attention to the development of designs on which the actual work of construction is to be done in a private factory, it is only in the stages already referred to as (4) and (5) that the question of allocation of financial responsibility becomes critical.

The Most Satisfactory Mode of Experimental Procurement

The new law governing aircraft procurement has given to the services a freedom of action in seeking out the best never theretofore possessed, although it unfortunately does not permit the direct recognition of design rights. The Navy and War Departments have, however, authority to procure either designs or completed airplanes, for experimental purposes, and machines so purchased may be either of types already fully developed or representative of designs destined to be developed in detail subsequent to and under the provisions of the purchase contract.

If a choice between the two possible procedures is sought, it is found impossible to follow any general rule. There are some airplanes requiring so long a time and absorbing so much money in their development that the strain would be beyond the reasonable capacity of the average industrial organization and should, in all propriety, be shared by the Government through an experimental construction contract given as soon as the general outlines of the design have been brought to the point where prediction can be checked and said to justify favorable expectations. The same procedure can of course be used for lighter and cheaper equipment as well, and indeed for other articles than finished airplanes, but as a general rule, in the interests of a more expeditious development of a more perfect product, in the interests of the Government and of industry alike, it is to be shunned in favor of construction by the manufacturer, upon the manufacturer's own responsibility, and subject to the manufacturer's sole control and supervision.

In indicating this as the most satisfactory mode of experimental procurement, there is no intention of endorsing a measure or procedure designed to weaken the industry or to throw an unrequited financial burden upon the industry's component organizations. Nothing could be more shortsighted, or less in the interests of the Government service, than unfair treatment dissuasive of a good initiative in the quest for improved design. As a matter of fact, under any fair and fairly administered policy the ultimate financial relationship should work out in substantially a constant fashion, for it is to be accepted as axiomatic that, regardless of whose checkbook may show in its stubs the original record of original expenditures, the cost of all experimental development of aircraft intended for naval or military functions will ultimately be borne under some guise by the Government, and that is only as it should be. Whether such costs are to be covered through direct and immediate payment or through gradual amortization spread over a series of production contracts, is a question to be decided not in terms of financial benefit for either party, for in that respect there should be an appreciable effect, but in the light of considerations of convenience and of the effect of the decision taken on expeditious forwarding of the experimental program and on economical employment of the contractor's staff and factory.

The fundamental problem of the experimental contract is the problem of divided responsibility. It could scarcely be regarded as expedient, even if or when it were legal, for the Navy or any other Government department to turn over a certain stated sum of money with the injunction to go build an airplane and let the department in question know when it was finished. The institution of a contract involves immediately the making by Government personnel of a detailed check of the design with respect to its aerodynamic and structural qualities. It carries with it as a corollary the maintenance of Government inspection over the processes of manufacture. It requires governmental assent to all changes of plan, which are likely to number scores if not hundreds before the set of drawings first submitted has been transmitted into a satisfactorily operable airplane.

When the contractor builds his own machine, subject to an implied understanding of probable interest in the type on the part of the Government, all of that complication, which means delay, delay which in turn means added expense direct and indirect, is swept away at a stroke. The machine issues forth as a completed article backed by the judgment of a single organization which must assume full responsibility and stand or fall upon the merit of the product. If success is attained, the Government purchases at a price fairly representative of the cost of constructing an experimental unit. If failure is the outcome, the constructor can only blame himself and try again. The procedure is one by no means new, for it has already been applied with conspicuous success in several instances in dealing with new and privately developed types of airplanes and of engines. It gains in attraction with added experience.

Experimental Development Should Be Carried Forward With Increased Vigor

Whatever the method that may be used, and it may well be found advisable to vary it from time to time or from contract to contract or from contractor to contractor to cope with particular

local or temporary conditions, it is urgent that experimental development both in design studies and in the construction of sample machines should be not only continued but carried forward with a considerable increase of vigor if American aeronautical engineering and the American aircraft industry are to maintain in all fields that proud place which they have so conspicuously won in some, and their right to which all Americans interested in aeronautics would so much like to see the industry and the engineering profession repeatedly reestablish and confirm. Both in airplanes and in engines our progress has been notable indeed, but to be positive of keeping at least abreast of the rest of the world, we must test out as many new ideas of promise and send to trial as many modifications in service design as go forth from the shops and drafting rooms of other lands. It is somewhat disquieting to discover that in a period of three years time there have proceeded from the aircraft factories of the United States pursuit machines from about eight substantially different designs, the total being the work of four separate manufacturing units, while each of two European countries can substantially double those figures both as to number of designs and number of factories concerned, and even one of the smaller powers a "succession state" of the Austro-Hungarian empire, has to its credit five distinct pursuit designs built by three different companies in the same interval. Observation, bombing, and maritime patrol machines show an unpleasantly similar record. The need for augmenting the amount of experimental design and construction is one over which I feel serious concern, and I hope that that concern will also be felt in the industry and that we may look forward to an energetic cooperation between industry and Government in order to get as large and diversified a return as possible out of the funds allocated by the Congress to experimental work to be carried on with the support of the service.

TESTS UNDER SERVICE CONDITIONS

Reverting to the scheme of classification initially drawn up, and picking up the thread at section (6), the next stage after the completion and preliminary performance trials of an experimental machine is its test under service conditions, a test which can best be given on about enough airplanes to fit out a squadron, in order that a number of pilots may have a chance to try the new type and pass judgment upon it and in order that the trial may be varied and extensive within a space of time short enough not to advance the plane unduly far along the road toward obsoleteness of design before decision has been reached whether or not to enter into quantity production. Inexorable pressure of time and shortage of equipment have occasionally harassed and constrained the Department to a compression of the three normal stages of procurement, experimental construction, service test, and regular production into two or even into a single one, but such condensation of the trials is fraught with hazard and is to be engaged in only as a measure of genuine necessity.

WARTIME REQUIREMENTS MUST BE KEPT IN VIEW IN PLANNING PROCUREMENT

The step from service test to regular production explains itself. Less apparent, perhaps, is the distinction between normal production for normal needs and what has been referred to as mass manufacture. It would be easy to give to the airplane but seven stages of life, corresponding to Shakespeare's classification of the years of man, and to ignore that condition of fevered production characteristic of the strain of war, a condition which becomes a reality at any time for only a very few airplanes which happen to be standard at the moment when a national emergency arises, but which has always to be kept in mind as a potentiality for every design adopted. It would be easy to ignore it, but to do so would be to ignore the Navy's real mission and primary function, which is that of invariable readiness to meet any call upon any notice, however short. To meet the call coming on naval aviation in the event of war would mean the multiplication by twenty- or fiftyfold in the least possible number of days of the production of naval types of aircraft. Such expansion is possible only if the way is prepared in advance, only if there is a clear conception at all times of exactly what would be done in the event of war, and of what orders would be placed and where, and only if there is consideration both in the governmental service and in the industry, at the time when airplanes are in embryonic development, of their adaptability to production by machinery in hundreds or thousands, instead of in dozens or scores. The production of airplanes is a highly specialized art. From the starting of a design to the acceptance of the corresponding type as a service standard occupies anything from two to four years. The acquisition of satisfactory standard types and the detailed plans for the use to be made of each of them in the event of emergency are not to be neglected in peace, for they cannot be extemporized in war.

TWO DISTINCT AIRPLANE INDUSTRIES, INDUSTRIAL AND MILITARY, UNDESIRABLE

This need to keep wartime requirements always in mind in planning procurement of naval aircraft under peace conditions has another bearing. It renders it undesirable in the extreme that there should grow up in this country, side by side, two distinct airplane industries, one building for a military and the other for a commercial market. Admitting the different qualities of material and workmanship now exacted in products of the two classes, admitting the difficulties of administration both of factory and of selling organizations that exist when a single company tries to operate in both markets, it still remains true that in the event of a real need for military aircraft we should have to mobilize the entire resources of every organization and individual of any experience in aircraft production, and the usefulness of any particular unit in application to a program of military procurement would be broadened and enhanced proportionally as the personnel of that unit were dowered with knowledge of the characteristics of military airplanes and experience in the special problems arising in their design and the installation of their equipment.

Looking at the same problem from the point of view of the industry building for naval and military demand, the manufacturers in that group are confronted with two alternatives. They must get into the business of building commercial aircraft on some terms, or they must see themselves steadily shrink in relative importance. While it is unsafe to prophesy for many years ahead, the authorizations now on the statute books provide for a procurement by the naval service (and by implication by the Army also, although the annual procurement numbers are not exactly stated in the Army Program Bill) of a gradually increasing number of airplanes each year for four years to come, followed by a distinct decrease to a total sufficient to maintain the amount of service equipment at a constant figure. In any case, it is hardly to be expected that there will be a very rapid and long-continued increase in the number of airplanes purchased annually for naval and military needs, whereas if the promise of the present moment materializes, it is not unreasonable to anticipate a commercial market growing by leaps and bounds until, if a sharp division of the industry into two parts were to exist and be perpetuated, the commercial portion would quite overshadow the military one. Such an outcome would be to the taste neither of the manufacturers nor of the services which are vitally concerned with being in a position to avail themselves of the talents and the energies of *all* the strong and progressive organizations

in the airplane-manufacturing field, not merely of the specialized groups dependent upon Government business alone to remain active.

The shipbuilding trade furnishes an analogy, although an incomplete one. A yard which confined itself solely to naval business would have known, following upon the Conference at Washington, even leaner times than the shipping industry as a whole has actually encountered during the past six or seven years. Conversely, a yard concerning itself only with oceangoing commercial craft would have been unable to share in the benefits of naval construction, sometimes reaching high tide when merchant building is at the ebb, and such yards would be able to take over the building of destroyers or other specifically naval craft in the event of war only with much more lost motion than would exist if the organization had already had a chance to gain some little experience in that field in peace times.

COOPERATION OF GOVERNMENT AND AIRPLANE INDUSTRY

The building of commercial airplanes has happily escaped from many of the tribulations and handicaps that have lain so heavily upon American merchant shipbuilding. With the airplane industry as a whole the Government is in sympathetic relationship and cooperation, with better American aircraft for all purposes as the goal. We have no intent of taking from the private constructor the responsibility which should properly be his, nor of laying on him the burden which should properly be ours. We believe in putting him in a position to use service experience as a guide, in encouraging his initiative to the limit, and in availing ourselves of the fullest possible degree of its result. In the light of eight years of post-war experience, of the progress of aeronautical engineering in that time, of the growth of interest in commercial flying, of the increasing strength of the aircraft industry, of the passage of the five-year program, and of the new procurement legislation, we speak with confidence of an existing and continuing advance toward the stabilization of a situation which will bring economy to the Government, efficiency and assurance of a source of supply to meet any demand, to the contractor profit and encouragement, and to the community at large a guarantee of the availability of aircraft for the national defense and for national service in peace or war.

A Water-Level Gage of the Long-Distance Recording Type

IN A PAPER bearing the above title which was presented at the Spring Meeting of the A.S.M.E. in Pittsburgh, the author, E. B. Strowger,[1] described a water-lever gage of the long-distance recording type, consisting essentially of two Selsyn motors, one called the transmitter and one the follower, together with a float and a recording device. The transmitter is located at the point of measurement and the follower at some central point where the record is to appear. The position of the rotor of the transmitter is controlled by a float. The follower motor operates a pen carriage which records on a paper with suitably scaled divisions. The motors are essentially induction motors with wound rotors excited from a common alternating-current source. The rotor of the follower will follow the transmitter rotor due to the induced currents in the stators.

The paper, which was published in the May, 1928, issue of MECHANICAL ENGINEERING, p. 365, also gives important details for the proper functioning of the gage, as well as drawings and photographs showing gages at present in operation. A summary of the discussion brought out follows.

J. J. TRAILL.[2] The gage described in this paper, as the author states, is an application of equipment used for other purposes as a solution of this special problem. Selsyn motors have been used in a number of other instances as the energizing moments in long-distance recording gages. In this particular case the writer takes it that the further variation shown by the author is the addition of the recording element described.

Provided that the distance between the transmitting and receiving portions of the equipment is not great, this type of gage has much to recommend it; but, as it requires five wires to be carried between the two elements, it will be evident that for transmission in excess of a few hundred yards the method is expensive. Furthermore, the Selsyn motor itself is not an inexpensive piece of equipment, and the writer questions whether, if economy is considered, it would be able to compete successfully with other methods of obtaining the results that are here sought. These objections to the use of this type of gage are prompted by the results of some investigations made in an installation on the Queenston-Chippawa Development at Niagara Falls, where the transmitting and receiving instruments were about eight miles apart. For such an installation the cost of the five-conductor cable would have been a very considerable item, and instruments available from various instrument makers of suitable equipment were found to be cheaper, since three conductors only were required. In this instance, however, one of the standard articles of commerce was not used for the installation, but a gage was developed which is used in connection with the private automatic telephone exchange. It is not proposed to describe the gage here, but simply to outline its application and explain certain of its advantages. It will, however, be necessary to state that the common type of gage well and float, phosphor-bronze tape, and counterweight are used at the point at which it is desired to measure the water levels. The sprocket wheel, connected with phosphor-bronze tape, controls a drum bearing ten strips, partly of brass and partly of non-conducting fiber. Upon each of these strips rests a spring, and each upward movement of the float of one-tenth of a foot puts an additional spring in contact with a brass strip. To this first drum is geared a second with a 10:1 reduction, thus giving a means of indicating changes of elevation at intervals of one foot. These are used with the automatic telephone to give a record of water level at any desired distant station. By making a call in the usual way on the telephone, a switch is closed, which causes a motor at the gage to commence operation, and this permits an audible record to be obtained for each of the contacts on the drums that is energized. Each contact on the second drum gives a signal in order, the total number of these being equal to the number of even feet that the float is above zero, followed by a series of signals with a different time interval between them for the "tenths" drum. The count of these thus gives the elevation

[1] Assistant Hydraulic Engineer, Niagara Falls Power Co., Niagara Falls, N. Y.

[2] Engineer of Tests, Hydraulic Department, Hydro-Electric Power Commission of Ontario, Toronto, Canada.

of water at the gage well above zero in feet and tenths of a foot. After the signal has been repeated a number of times, the motor is automatically shut off and the telephone circuit disconnected.

The special advantage of this arrangement is that a call may be put in from any point on the system. In the particular instance under consideration it is necessary for the operators in the control room of the power house to have records of the water level at the intake of the plant, and it is also necessary for these records to be available at the load despatcher's office, at which the control for three plants is located. It will be seen that the arrangement is very flexible, as the location of the load despatcher, or of any other interested officer, is only controlled by the location of the telephones in the system. For example, it has been necessary at times to obtain records of water level at the head office at Toronto, eighty miles from the plant. To obtain these records, it is simply necessary to call the switchboard on the private telephone line and ask for the telephone number corresponding with the gage.

The method has another advantage that is lacking in the case of the gage described by the author and many other long-distance recording gages. In these, if the current to the gage is interrupted for any reason, and the water level changes before the power supply has been restored, the gage may not give the correct reading. The author states that if the water level has changed less than two feet in the case of the Selsyn-motor-operated gage, the gage is self-restoring. In many gages the self-restoring limit is much smaller than this. The audible gage, however, is not subject to error for this reason.

In dealing with the conductors required for various types of gages, it was stated that only two were needed for the audible gage. In a sense this is only partly true, as four wires lead into the sending station of the gage. Two of these are the telephone cables, and two give 110-volt a-c. power for the motor. The power supply is available at all stations at which these gages are installed, five in number, so that the statement is practically true; but this could not be the case if the gage were at a point remote from power supply.

The gages were designed and built by members of the operating staff at the Queenston Development.

CARROLL F. MERRIAM.[3] This subject is particularly timely and the writer believes many companies would find it profitable to give attention to the long-distance transmission of water-level indications. The Pennsylvania Water and Power Company has had in operation for nearly a year, two long-distance water-surface-level transmitters very similar, as far as the Selsyn motor is concerned, to the application described by the author. Formerly a man was sent to take hourly readings in connection with other duties. Now we have both forebay and tailrace indications on dials located at the control board. We found that there was not only considerable delay in securing readings, but also that hourly readings were frequently affected by previously unsuspected periodic swings in the forebay level, which happened to have almost exactly an hourly period. Furthermore, not only does the use of the transmitter avoid delay in getting the information to the load despatcher, but also readings can be taken more accurately, particularly at night if the water is very clear or during the winter if the staff gage becomes coated with ice. There is much less danger of a false reading giving trouble, as readings can conveniently be checked without necessitating a special trip to the gage.

The apparatus used was constructed by Julien P. Friez & Sons, of Baltimore, who adapted the Selsyn-motor transmitter to one of their regular water-stage recorders, which may be either of the Au-Fuzee type or the continuous recorder with paper travel adjustable independently of the clock, a model which has been developed since our installation.

In our case the recorder was located at the sending end for the reason that we were willing to sacrifice the convenience of having the recorder at the switchboard for the sake of greater precision in the graphical records necessary under our special conditions. Where this accuracy can be sacrified, it is advisable to have the record at the receiving end, as shown by the author.

At first we feared that the "field of inaction," which the author assumed to be 4 deg., would introduce sufficient error to cause trouble, as under our conditions an error of one-tenth of a foot may cause an overestimate or underestimate of the river flow, of about 5 per cent during moderately low flow. It is possible that when the Selsyn motor drives the recording mechanism, there may be appreciable error caused by backlash and "field of inaction." Our experience with indicating instruments, where the motor is directly connected with a pointer instead of driving a mechanism, is that the "field of inaction" is inappreciable. Some idea of the amount of torque set up may be had by displacing by hand the rotor of the receiving motor from the position occupied by the sending motor. The rotors behave as though connected through strong elastic bands.

It has been our experience that a relatively large proportion of the expense in the entire installation is in providing a float well and electrical connections, and therefore, inasmuch as instrument makers now have seriously taken up this line of work, it is more economical in the end to purchase the instrument rather than to build one with whatever shop facilities may be at hand. However, the author shows what it was possible to accomplish before such instruments were commercially developed.

It would be interesting to see whether or not the stator leads of two sending motors could be connected to a three-phase synchroscope to show directly a differential indication such as head.

R. L. SACKETT.[4] There are other fields than power in which remote indication of gage heights is quite important, for example, in water supply, where high and low elevations in raw-water and treated-water reservoirs are desirable.

In most instances dependence has been placed upon direct indications, but there are certain electrical devices similar to the one described by the author which have considerable advantage because of the reduced amount of friction in the apparatus. Where only one indication of high or low level is desired, a simple three-wire system is possible using two floats, and a spark which punctures a paper record and gives the indication of high or low, together with the time when high or low is reached. Its application to the problem given in the paper has the disadvantage that the number of circuits increases to a point where it becomes uneconomical, and the question arises whether the method might be simplified somewhat and the number of circuits reduced.

A. J. ACKERMAN.[5] The author states that the transmitting system is essentially a five-wire arrangement. The writer would like to raise a question regarding the voltage requirements on the Selsyn armature. It would seem that in nearly all cases either lighting or power supply is available at the headworks for gate operation and that as long as the supply is synchronized with the rest of the system, that supply could be used for the Selsyns, thus requiring only three wires to run from the transmitter to the receiver.

[3] Pennsylvania Water and Power Company, Baltimore, Md. Mem. A.S.M.E.

[4] Dean of Engineering, Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

[5] Aluminum Company of America, Pittsburgh, Pa.

D. R. Yarnall.[6] We have had a good deal of experience in building recording apparatus in connection with V-notch meters and rectangular-weir meters, and ask whether it would not be better to use a solid displacement rather than a hollow float, thus eliminating all possible chance of leakage and obtaining very sensitive operation if the apparatus is properly designed.

R. L. Thomas.[7] One point in the author's installation is unique, namely, the recorder is at the receiving end. At Conowingo they have a Stevens gage which uses the Selsyn motor, but there the recorder is at the sending end and at the switchboard they have only an indicating dial. In this case the gage is used chiefly to determine manipulation of crest gates. It is important that a certain pond level should not be exceeded, and for that purpose the operator really should see the trend of pond-level changes as well as the instantaneous reading, because while a dial will show the instantaneous reading, it does not indicate whether the level is rising or falling. Further, in estimating the flow at hydroelectric plants, stream flow is determined by using the turbines as water meters and taking into account the change in storage in the pond. And in a short time interval such as one hour, a small change in pond level represents considerable flow. Here is another instance where accurate indication of water level at the switchboard is very desirable.

One interesting point brought up by a plant superintendent of long experience was that he wanted the operator to make an hourly trip through the plant from the switchboard to the tailrace gage and the headwater gage in order that some one would go through that section of the plant every hour, whereas if the gage were right at the switchboard, he would not have to leave the switchboard and he might not make that hourly trip through the plant.

This objection to determining flow by taking into account the change in the pond level could be eliminated by having a long-distance gage clear above the effect of the backwater from the dam. That involves distances greater than the backwater affects. In the case of the Pennsylvania Water and Power Company development in Susquehanna River, it means transmission of about nine miles. Of course five wires there mean quite a good deal, because there is no power line up to that part of the river. So the elimination of two or three of these wires would be highly desirable.

One advantage in the type of gage which has not been emphasized, is the absence of all moving contacts. This is the great advantage of the Selsyn motor scheme.

L. F. Moody.[8] One way in which the action of the headwater could be transmitted conveniently in the plant would be by an air column—compressed-air transmission through a pipe. One interesting case where that has been used is not for the purpose of a recording gage, but to put in a secondary control on a governor in a plant. There is a plant in South America where the conditions make it necessary for the load to be regulated on the unit in order to control headwater and keep it at a certain point within limits. To do that they have a float in the headwater which communicates by a compressed-air column through a very small pipe led down to the station and with a diaphragm or second float in the governor, and this has been found very satisfactory and to give no trouble. It does not freeze up in winter and is an excellent means of transmitting pressure from one point to the other. The same device could be used for the gage.

[6] Yarnall-Waring Co., Philadelphia, Pa. Mem. A.S.M.E.

[7] Assistant General Superintendent, Pennsylvania Water & Power Co., Baltimore, Md. Mem. A.S.M.E. and chairman of session.

[8] Consulting Engineer, I. P. Morris Corporation, Philadelphia, Pa. Mem. A.S.M.E.

In regard to Mr. Thomas' point, would it not be possible to have merely the control gage, say, at a point several miles away, so arranged that it would close a telegraphic alarm when the level reaches the danger point, and merely have a single circuit to transmit that alarm signal to the power house? It seems that much might be done along that line by having recorders or registering meters at critical points with electric-circuit alarm control which will give a signal at the power house when some critical point is reached.

Author's Closure

Replying to Mr. Traill, regarding the necessity of five wires between transmitter and recorder, if the source of supply at the head works is the same as at the central point, where the record is to appear, then three wires only are necessary. This of course would cut down the cost considerably. The Selsyn motors cost approximately $75 apiece, making an investment of only $150 in the two motors.

With the silver contacts used there is practically no resistance and no trouble.

The accuracy of Mr. Traill's gage of a tenth of a foot, due to the fact he used ten strips on his tenth drum, would be a handicap to some systems, for instance, at Mr. Thomas' plant at Holtwood, where one-tenth of a foot represents considerable storage. And it would probably not be accurate enough for establishing the value of average head at the plants of the Niagara Falls Power Co., where we are dealing with an output of 500,000 hp. in one plant. A consistent error of one per cent would be a considerable one in reporting water to the Government, either penalizing the power company or the Government. Mr. Traill's device seems to be similar to the "mechanical man" at Washington.

Another disadvantage regarding Mr. Traill's gage is that it does not give the trend unless the operator in the control room calls up the station perhaps every 10 or 15 minutes. That would certainly increase the number of attendants necessary at the power plant. The load despatcher is too busy to call up every fifteen minutes to get the water level at remote points of the system. The load despatcher in the control room in our case has his record in the same building, and it is practically under his eyes.

Unless a man using the system described by Mr. Traill calls up at frequent intervals and plots the curve, it does not seem possible that he can accurately determine the trend.

Reference was made to the restoring feature being two feet in the case of the gage described. That is, if the power supply fails and during the interim the water level changes two feet or less, the gage is self-restoring. It was stated that in many cases this restoring feature is made for a change of levels of less than two feet.

That is true, but the accuracy of the gage is sacrificed when this is done. The greater the restoring feature, the smaller the accuracy. This is due to the period of inaction, to the fact that equilibrium is approached between the two motors; in other words, as the torque approaches zero, any friction introduced by the drag of the pen on the record paper or friction of the gears, etc., has a negligible effect in causing an error dependent upon making this angle of inaction as small as possible.

Mr. Merriam seems to confirm the desirability in general of the Selsyn type of water-level gage. The company he mentioned, it is understood, is about to put on the market a gage which records at a remote point; up to date their gages record only at the site.

The 0.05-ft. error in the present design could be eliminated perhaps by changing the relation between revolutions of the float and the range of the gage change. For instance, instead of having

4¾ revolutions per foot change in water level, this could be increased to say, ten, and it would make the accuracy of transmission around 0.02. There is hardly any limit to the accuracy obtainable with this motor gage; 0.01 ft. is possible.

Dean Sackett mentioned a type of gage which I believe utilizes electrical contacts of the make and break type. These are undesirable in a gage. The spark at the contacts has been eliminated to a great extent by condensers, but condensers and contacts should be eliminated wherever possible.

In answer to Mr. Ackerman, as long as the supply of 110-volt alternating current is the same at both the foreboy and the control room or central point, the three-wire system is applicable.

As stated by Chairman Thomas, the gage described in the paper stresses the point of a continuous record at the receiving end. In our case it is in the control room, where half a million horsepower is despatched.

In regard to the desirability of a man's taking an hourly trip through the plant—and this man might just as well take hourly readings of water level in order to give him an incentive or reason for making these hourly trips—we have a man who makes a daily trip and he looks at every water-level gage on the system together with other duties that he has for the day. At nine o'clock each morning he begins to inspect every gage whether it is automatic or not. In this case he performs a multitude of tasks. This task of inspecting the gages is only one of many, and the particular gages to which he pays most attention are not the Selsyn motor gages but are other gages which record at points, these points not being of interest to the men in the control room.

The point brought up by Mr. Makenzie that the human element enters into the record with some designs applies to Mr. Traill's case to some extent. There might be a small interval between the time that a man calls up the "mechanical man" to get his record and the time he puts it down on paper or records it. This is trivial, but it must be considered.

The economics of the installation depends to a great extent on the type of plant and the investment therein. In the Queenston plant, the development consists of nine units each of 55,000 to 57,000 hp. There is scarcely any doubt but that in a plant of that size the installation of the Selsyn type of long-distance recording gage would be justified, because the operators would not have to call up every fifteen minutes if they had an automatic record constantly before them.

Some Common Delusions Concerning Depreciation

IN A PAPER presented at the Spring Meeting in Pittsburgh and published in the May issue of this journal, Ernest F. Du Brul pointed out the effect of inflation of currency in creating illusions as to depreciation accounting. He showed the fallacy of usual accounting practice that takes into cost a depreciation allowance based on the original cost of fixed assets, and the necessity of calibrating the dollar measure of value consumed during each period, to allow for changes in the purchasing power of the dollar.

Mr. Du Brul showed how the present common practice results in overstatement of real profits by understatement of actual depreciation in some cases, and vice versa in others. He also showed graphically the difference between dollar accounts that are uncalibrated and those that are calibrated for purchasing power, using the depreciation and net profits reported by the U. S. Steel Corporation to illustrate the point.

The discussion which followed the presentation of the paper was extensive and varied, and appears in substance below.

GEORGE I. ROCKWOOD.[1] The reason we are so deeply interested in the value of money from one year to another is because it affects the returns that we think we ought to get for the goods we sell. The public decides the question of price of what we have to sell and have to know whether we dare to take that price.

I have devised a method for our company's use which comprises a zero and a sub-zero cost, both far below the book points of departure either way, profit or loss. Our accountant says, "You must take account of obsolescence and depreciation in your cost," and I reply, "In that particular department they are not doing any work and we have to take in some business, and if we don't, how much money shall we lose?" On his theory we shall lose money anyway, but I show him the overhead stops at a sub-zero and that when we get down to a certain point we are going to lose money if we don't take the job, and lose money if we do take it. There is where we stop bidding anyhow. From there upward it all depends on the state of one's business.

As to obsolescence, we have the very first automatic-spindle turning lathe that we started in business with twenty-four years ago, and it has been rebuilt about four times. You would say that we couldn't afford to rebuild it. We couldn't afford not to rebuild it, because we did it in slack times when we were doing everything in our power to keep our men employed.

WILLIAM ELMER.[2] It was indeed a pleasure to hear Mr. Rockwood state that there are various bases on which costs should be determined and that sometimes it is necessary to take work at a loss, which is the basis on which railroad charges have been made in many commodities. It certainly is reasonable to charge more for diamonds than for coal or ore, and the principle of charging just exactly what the cost is for transportation of any commodity is a matter of such intricate difficulty that I doubt whether the most expert accountants or the most sensible business men could determine how the railroad costs are actually made up. For instance, a few years ago I was a master mechanic, and naturally, my salary had to be distributed over the freight and passenger service. How much of it should have gone to freight and how much to passenger? That is merely one of the little incidental problems that have to be solved.

ALEX DOW.[3] This very timely paper draws attention to a confusion of thought that exists not only in machine shops, but elsewhere. It draws attention also to the habitual ex-post-facto attitude of mind of the accountant who is dealing with accomplished facts and is not often looking forward to the future.

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[2] Special Engineer, Pennsylvania Railroad Co., Philadelphia, Pa. Mem. A.S.M.E.

[3] President, Detroit Edison Co., Detroit, Mich. President A.S.M.E.

You may say that the making of the record must be complete. There is always the problem of accounting for what money and what other valuable property has been received, but that is only a record. That accounting does not indicate what is being done today or what must be provided for in the future.

The attempt to coordinate the record with the provision for the future has been made in many ways according to many theories and it has resulted (in my opinion) in the discovery by those who are face to face with the problem in a large and varied number of forms, that what is required is realization of relativity; that there may be parallel lines of accounting which may become tangent, or can be coordinated here and there, but which do not normally progress (so to speak) with the same velocity and which absolutely cannot be referred to any one common standard.

Setting aside questions of differential between stockholders and management and assuming that the management is dealing with the property of investors in the property as these may appear, we find that we must make provision for several things that are not the same but which by muddled thinking, to which our accounting friends have given a great deal of encouragement, are supposed to be the same.

We speak of depreciation. Very good! It is probable in any given case. The method of providing for it is a question of the exercise of judgment and it cannot be set up as a mathematical formula generally applicable, and certainly it need not be coordinated with the records of past expenditures.

If, however, a retirement reserve is being set up (as certain public utilities are required to do) then it absolutely must be coordinated with past expenditures. Such a reserve is set up so that when a certain unit ceases to be useful it can be written off, and that this can be done without drawing down surplus or impairing invested assets.

If you are eating up a replacement reserve, you must immediately apply the formula that has been presented by the author, namely, what will it cost to replace the worn-out or obsolete article? The difference between retirement from the accounting record and replacement with an equally effective unit is very obvious.

Depletion is still another matter. If we are pumping out gas wells or oil wells, or mining out a good vein of coal, we must set up a depletion account as we go along because depletion must be included in costs and ought to come out of earnings.

Finally there is the broad requirement that the investment shall not be impaired. Even the paper, with all its clear thinking, is lacking to a certain extent in that it fails to consider depreciation from this angle. Banking practice is perhaps the best guide here. The banker looks over his investments, and rerates them month by month "at the market;" he is under supervision of a constituted authority and is told that for the bonds and commercial paper and other securities that have ceased to have initial value he must make good. That is again something else different from retirement, depletion, or replacement; although depletion runs into it at a great extent and each of the others into it at a lesser extent.

Last of all, there is accounting for taxation. The insistence by the Internal Revenue Department of the United States Government is that the claimed allowances for depreciation, obsolescence, etc., shall be reflected in the accounts of the taxable year. They ask us to put our accounts into the red if we have had a bad year in which there has been a large accrual of obsolescence, and they do it on the assumption that accounts have to be closed year by year. They set up the year of our Lord as an entity, while it is nothing more than a convenient division of time, having no rights, nor sanctions, nor duties, and no standing in court or before any constituted authority. Why any business concern should be required to write off its books and put itself into the red items of accrued depletion, or obsolescence, or any similar accrued factors of its cost for the year, when it hasn't earned the necessary amount to cover these items, is beyond comprehension.

Taxation accounting, therefore, absolutely should stand by itself. Depreciation and obsolescence should be capable of proof. That tax account should be closed as of the year because the law so requires; but that it should be tied into the other accounts and reflect in the year's accounting the accrued depreciation which it is not necessary to make good in a troublesome bad year, a year of poor profits—that general accounts should set up a charge against the year that will make it appear that a dividend paid out of surplus has been unlawfully paid—that such a rule should even be suggested is absurd, but it has not only been suggested but recently insisted upon.

A final point is the difference between surplus and reserves, as to use in making-good losses. With money or values in the reserves, there is absolutely no difference. Whether provision for obsolescence, retirement, replacement, impairment of investment, etc. shall be allowed to pile up in surplus or shall be earmarked by the setting up of a reserve account is, to my mind, a question of business policy. The important point is that the management or directors shall not fool themselves.

Like the railroads, my own particular industry, electric light and power, has suffered to some extent from regulation by amateurs. However, there is a residuum of educated staff in most of the commissions now. If the Interstate Commerce Commission will abandon the idea that it is a court of last resort and thus on a par with the United States Supreme Court, and will decide quickly the problems before it, it will be a great relief to the railroads. There are signs that this is coming about.

The point I would make at this time is this: Cost accounting should coordinate wherever there is possible coordination with record accounting, and it must include provisions for depreciation in whatever form these may take. But when the problem comes up of keeping things going and the organization together, cost accounting is absolutely what we have to go by and it has to separate itself into overhead, continuing costs, minimum irreducible costs, sub-zero costs, and the increment costs which will be added by additional business. The railroad companies know very well in their legal departments that their position in that respect has been approved by the Supreme Court in a whole succession of decisions. They are in a position where they can make a rate for a line of business they hope will develop and become profitable. They may make a special low rate for that so long as it does not impose a burden on other lines of business; in other words, so long as it pays the increment cost of handling the additional freight or passenger traffic. The authority of the management to make such a rate is unquestioned and has been since the North Dakota lignite case and several other later decisions.

They cannot, however, be compelled to make such a rate. A public utility cannot be compelled to make a development rate. Cost accounting, in making such a rate, must furnish an accurate record of the increment costs. The railroad man says, "If I have to handle that, it will cost so much equipment, so much maintenance, so many crews, a small charge for wear and tear on rails and a little congestion here and there, and the total new costs will be about thus and so," and that is the increment cost. The judgment of the rate-making authority must take the increment cost as his basis and see that he recovers the increment cost.

It is the same in the machine-shop business. If you want to take a job and you know it will cost so much to do it on top of your overhead and the shop is rather empty and things are not very promising and the situation is highly competitive,

the one problem before you is how much more than increment costs can you get in your selling price.

In my own work I set up the rule long ago that there was only one way to be sure that I got the legally required increment costs, and that was that I would be able to show I had made a small amount above that. The price received had to be a little above the calculated increment costs in order to satisfy myself that the job had not become a burden on other jobs.

Out of the discussion about public-utility rates and costs, there has come the idea that the costs should make the rates. The point was very well made by Mr. Elmer that you cannot expect to charge the same rate on coal or ore that you charge on highly valuable freight. For example, silks carried in a fast train and under special guards should pay a very fair price, and the cost of handling silk as compared with the cost of handling ore and coal need not be used to establish the rate, for the business will carry more.

The principle of "what the traffic will bear" is that the profitable commerce must in the general interest of the public carry some part of the overhead charges, including necessary return on investment, which has to be incurred in order to serve the necessities of the ultimate consumer. We must avoid the mistake of assuming that our average costs, including depreciation, must be earned on every job.

R. M. BRYAN.[4] Regarding boiler depreciation, according to the author, what should occur is that as each boiler grows older, a certain amount of money should be carried in reserve to replace it when it has to be discarded. At the Carnegie Homestead plant nearly a hundred boilers gave out at about the same time in about four plants. Each plant had its own ash house, coal-handling equipment, water-purifying plant, and so on, and instead of replacing each one of those, one boiler plant was built to replace the four, and on the whole the company was probably something in pocket because of carrying enough to replace each one and keeping the price up to date, and the putting in of but one large plant. Every time any part of the plant wants money to replace anything, it must show a saving before it can get an appropriation, and in that way the master mechanic and the men are always on the alert for any combination or way to combine two or three power units and thus cut down the cost of doing a certain amount of work.

A. H. BASS.[5] We have come through a period of rapidly rising prices brought about by the World War, and the equipment in our shops today which was bought during the last eight or ten years, stands there at a very much higher value than the same equipment would have stood had it been bought prior to this period. In ten years to come, however, we may have a reverse situation in which we may be paying but two-thirds of what we are paying for the same identical tools today, and I am wondering if in a case like that the author would begin to pass credits to some of these costs instead of additional depreciation costs, and set his selling prices with those credits.

AUTHOR'S CLOSURE. I am very glad to answer Mr. Bass's question. It is a poor rule that doesn't work both ways. We have had both situations. It isn't only in just the last war period that we have had this changing price situation. It has only been more marked in that period.

Consider a plant built in 1913, which is taken as a base year nowadays because it happens to have been the last pre-war year. Taking the Aberthaw Construction Index or the American Appraisal Company's Index of building costs of 1913 as 100, the cost of an identical structure in 1920 would have been 250 and 200 in 1928.

Under the tax law the man who is trying to replace 1913 assets at double the money in 1928 has to take the difference in his depreciation figure as a profit. So he does not get square with that asset until he has paid 13½ per cent tax on top of that difference. The man who built in 1920 at 250 is presented with a secret reserve under the tax law because it costs him only 200 to replace, so the difference of 50 in his case is handed to him without tax. It is a real profit. The 1913 plant is taxed on a profit that is fictitious, and in the second case there is an actual profit that is fictitiously called a high cost by the tax law and is not taxed.

I have run into some very peculiar things. Some of the members of the N.M.T.B.A. built plants at 250 at the peak of prices in 1920. They are taking depreciation from the original cost, but they can't expect to lay down a comparison of cost and find whether they are making a real profit unless they figure it the other way around and take depreciation on the basis of present valuation of the plant.

It would be absurd, if a plant were put up at 100 and a duplicate plant were put up at 250 in 1920, to say the cost of operating the second plant was higher because of that. The depreciation is the same in both cases. How is the owner going to measure the relative efficiency of the two plants if he doesn't put them on the same basis? Suppose he wants to pay the superintendents a bonus according to the efficiency of their management—is it fair to the man who happens to be superintendent of the plant that was acquired at high cost, to tell him he is less efficient and his costs are higher on account of that situation? Not at all!

The thing to do is to raise the depreciation charge in the product of this plant to equal that of the other because that is the social value. If all the price levels change both plants should be equalized on that basis. So the formula is a reversible formula.

I am glad that Mr. Dow and Mr. Elmer brought out the question with respect to public utilities because it is a serious question. There is before the Supreme Court of the United States now the O'Fallon case which hinges on this whole question. A law has been passed penalizing the efficient railroads by taking away from them any excess earnings, and these excess earnings are supposed to be figured to allow the roads to make 5¾ per cent on the value of their property.

Now the Insterstate Commerce Commission has three methods of valuing the property of any given railroad, and they are all applied to the same road according to different kinds of property. They take the land value at its present worth, plant and building values of those assets that were acquired prior to 1914 at 1914 prices, and all buildings and machinery and other equipment acquired since 1914 at the cost of acquisition. There are obviously three different bases of valuation in following such a procedure as this!

If the Supreme Court continues to follow out its own rulings in other cases, they will say that the 1928 value is to be taken for all of them. The question was asked as to how often the valuations have to be changed. Here is a curious thing. It is recognized as being good business practice to have appraisals of property made by disinterested appraisers for insurance purposes. In consideration of a premium payment, the insurance company, should fire occur, will pay you a certain sum of money which is based on the reproduction value of your property less depreciation.

Destruction by fire overnight happens to be immediate destruction of all the productive value of the plant. Depreciation is merely slow destruction of that same item. So I can't see any lack of logic in figuring my depreciation on the same basis that an

[4] Carnegie Steel Co., Pittsburgh, Pa.

[5] Westinghouse Elec. and Mfg. Co., Swissvale, Pa.

insurance company will figure with me in my insurance. The accountants are beginning to think of this thing.

W. E. Dean, Jr.[6] asks whether the basis for the calibration would be the machine-tool industry or the general price-level purchasing power of the dollar, and how often that calibration might put into effect. What I have done in the paper is simply to take the New York Federal Reserve Bank's index as an indicator. That is just an index for ordinary commodities' purchasing power, and the reason it was used was because I was making the analysis from the point of view of the stockholders. When it comes to plant values, constructive indexes should be used. Costs on construction of all sorts are much higher relative to 1913 than this general-purchasing-power index.

No particular industry could be taken. Each industry ought to figure out its own indices, plant construction, equipment values, and so on.

Another point frequently raised by our accounting friends, is that we do not make our replacements in kind. It is not necessary. Of course we don't replace the same kind of machine, but we should certainly allow for the replacement of the same amount of productivity and if we don't do that, we have impaired our investment as President Dow has pointed out.

Replying to Mr. F. E. Cardullo,[7] I would say that the depreciation account should be kept in securities until it is spent for equipment, instead of being continuously invested in inventory or otherwise in the buisness.

We find in most cases that the theory of investing ready funds in the inventory and other liquid assets doesn't work out. In other words, inventories aren't as liquid as people generally and accountants and some credit men seem to think. They can't be cashed in at will.

Some organizations, however, are now beginning to point out to the bank credit men that unless depreciation reserves are something more than a mere book entry, they don't mean anything and for this reason many businesses, organizations, and trade associations today are educating their people on three points:

1 To take the depreciation money, whatever the rate may be, good or bad, and keep it in liquid securities as a real cash reserve so that it can be used when it is going to be needed;
2 To be sure to have the depreciation figured out according to the reasonable physical life of the asset; and
3 To calibrate the depreciation figure according to what is needed for the replacement of the asset in these calibrated dollars.

[6] Westinghouse Air Brake Co., Wilmerding, Pa.

[7] Chief Engineer, G. A. Gray Co., Cincinnati, Ohio. Mem. A.S.M.E.

Production of Bessemer Steel

WITHOUT going into an exhaustive analysis of figures it may be pointed out that the Bessemer is a very important steel-making process, but, with a slowly declining trend the percentage of the total tonnage has been decreasing until today it accounts for about 14 per cent of the total tonnage, or 19 per cent if the duplex steel is included. Duplex tonnage also appears to be slowly going down. This should really be placed in a different category, because it does not handle low-phosphorus pig iron nor make Bessemer steel, but treats higher phosphorus metal which is then sent to the basic open-hearth. The tonnage made of duplex steel depends closely upon economic conditions, principally the amount of scrap available for the open-hearth, its price, and the tonnage requirements of the individual open-hearth plants.

Confining attention to straight Bessemer steel, it is a material that offers advantages over other steels for certain purposes. This is particularly true when it comes to free-machining and welding properties. For high-speed automatic screw stock Bessemer steel has never been surpassed. The very large tonnage of steel used for automatic screw machine products seems therefore preempted by this process. The demand for such material is increasing, the steel being either hot rolled or, more usually, cold rolled or drawn. A comparatively new development is the use of such material for case-hardened products, with splendid results. Its free-machining, together with its good welding properties, makes Bessemer steel valuable for butt-welded and lap-welded pipe, particularly the smaller sizes which are frequently cut, threaded, and fitted in the field. A short, but rather general, questionnaire would indicate that Bessemer steel is holding its own in the field of skelp, particularly for making the smaller sizes of pipe. On the other hand, a demand for seamless steel pipe in certain sizes is causing the use of open-hearth steel; the specifications of many of the oil companies for open-hearth steel are also lessening the demand for Bessemer steel in tubular goods for the petroleum industry.

A large tonnage of Bessemer steel is being used for wire products, including wire nails, fencing, and the finer sizes of wire and a great deal is rolled into sheet bars for making sheets, tin bars and tin plate. Its inherent stiffness is often an advantage in wire or sheets, but for deep-drawing stock the dead soft open-hearth steel seems to be preferred. A considerable tonnage of Bessemer steel is still used in the form of bars, small structural shapes, and for railroad purposes, such as spikes, bolts, and nuts. The addition of copper in the usual amount of 0.20 to 0.30 per cent is fairly general for material which is to be used in places which are exposed to atmospheric corrosion, such as certain wire products, sheets, railroad material, and other special shapes.

In concluding this brief survey of the Bessemer steel situation it may be pointed out that the future promises that this method of steel manufacture will not only hold its own but improve its position. The reserves of Bessemer ores are larger than was recently supposed. As a method of steel making it is capable of good control, and for many purposes, as indicated, the steel offers advantages.

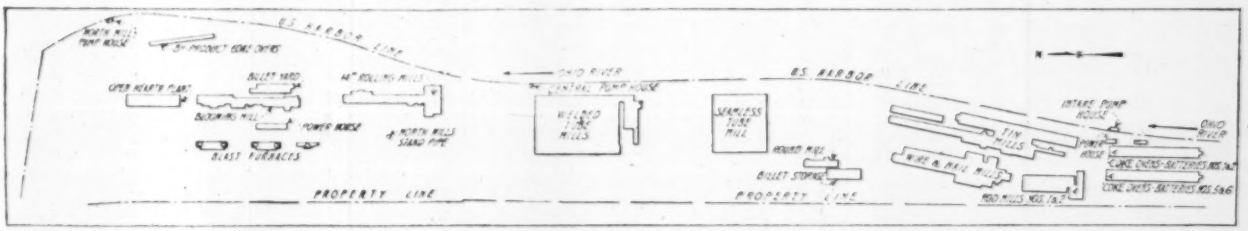
While considerable research is being carried out in order to improve the quality and extend the usefulness of Bessemer steel, there is need for still more work along these lines. Some of the methods used in making high-quality steels by the open-hearth and electric furnace can be applied to the Bessemer process, particularly in obtaining sound steel ingots and steel more free from non-metallic impurities than is usual at present. It is believed that, if proper attention is paid to having the right kind of pig iron, if proper and in some cases improved Bessemer plant and equipment is provided, and if increased care is given to the finishing of the steel, to ladle practice and pouring practice, the Bessemer converter will produce metal superior to the ordinary run of tonnage steels made today and increased uses can be found for such qualities. This, as mentioned before, will enable this method not only to hold its own in the fields now occupied, but will increase the tonnage made and the steel used in other lines now closed to it.—From an article in *The Iron Age*, July 5, 1928.

The Water Supply of Steel Mills

Statistics of the Water Requirements and Pumps Used in Three Steel Mills In Different Districts

FEW outside of the metallurgical industries realize how important is the water supply in the operation of a steel mill. Probably it was this factor as much as any other that determined the location of existing steel mills. It has been said that dollar-a-ton coal built Pittsburgh. There is no doubt that in the early days of the American iron and steel industry when plenty of sites were available and the cost of land was low, the industry gravitated to the place where the vital materials were cheapest. The one that presented the greatest transportation difficulties in those days was coal, and the steel industry had naturally to sit on top of the coal mines. It should be remembered, however, that the availability of very large amounts of water was also indispensable to the success of the steel industry at Pittsburgh as, without water, the industry could not have developed, even with plenty of cheap coal at hand.

As time went on, however, other conditions came to govern the location of steel mills. Some were built in the neighborhood of existing and successful mills, partly because these established a proximity to buyers and also because it made the labor problem somewhat easier. As the industry expanded, and particularly as the transportation rates began to skyrocket, there was a tendency to bring steel making as near as possible to the consumer's door, and plants were established in locations determined primarily by economic rather than physical conditions. This led to some difficulties when it came to the question of water supply.



PLANT LAYOUT IN THE PITTSBURGH DISTRICT

The majority of steel mills are using such water supplies as are naturally available. It is only in Cleveland that earnest consideration is given to the problem of developing such water supplies as might attract the steel industry, and it is not without significance that among those who are opposed to or at best lackadaisically inclined toward water-supply improvements are said to be the big steel companies. This is not due, of course, to any lack of desire to have more water available at a lower cost, but to the fear that the improvement in industrial water supply will act as an incentive for municipal and state authorities to increase the already serious burden of taxes on steel mills.

At Waukegan on Lake Michigan, water is taken through a 36-in. intake stretching into the lake for a distance of $1\frac{1}{2}$ miles. Every spring when the ice starts moving this long intake line is more or less damaged, involving a substantial expenditure for repairs.

On the Monongahela River where steel is made in large quantities, the water is so acid that it eats out the condenser tubes. On tug boats operating on the river, aluminum tubes have been tried with more or less success.

In the Shenango Valley water is as precious as in the artificially irrigated truck gardens of California. In the summer, particularly when the season is not very rainy, the river dries out to an extent sufficient to interfere with the operation of plants. Just why this is so is by no means clear to an engineer visiting the section. There is a region containing a lake and some swamps back of the Shenango River. It would appear to be a comparatively simple proposition from a technical point of view to put up a dam and control the flow in the river. For some reason or other, however, this is not done.

On the other hand, essential progress here and there is made in the solution of the water-supply problem, even where the natural conditions are not favorable. Thus until 1910 conditions were very bad at Youngstown. With three big steel mills operating in the district and a number of other plants using water, it was found that at times the water pumped was actually warmer than 130 deg. fahr., and any power-plant engineer will know how attractive, for example, is the operation of a condenser plant with "cooling" water of that kind. However, an 80,000,000-gal. reservoir was installed with the result that even in warm months the temperature of water does not run above 100 deg fahr. A second reservoir which is under construction will bring the water temperature down to a maximum of 85 deg. fahr. Under ordinary power-plant conditions this would not be considered a good temperature, and yet the feeling of operating men at Youngstown is that they have made a satisfactory adjustment to the conditions as they exist, and while they would like to have colder water in the worst months of the year, they do not feel that it would be worth while spending much money to get it.

Without a very thorough knowledge of local conditions it is, of course, impossible to judge how well founded such a fear is. It is stated, however, that the taxes on steel mills in the state of Ohio are already 25 cents a ton higher than in Pennsylvania and as much as 50 cents a ton higher than in Illinois. A further increase in taxes might, therefore, be considered as a serious handicap for Cleveland mills under the present conditions of intensive competition and low price level in the steel industry.

Few engineers outside of the steel-mill fraternity realize what vast amounts of water a steel mill needs. In the case of one mill covered in connection with the preparation of this article it was found that 1,000,000 gal. a day suffices for the requirements of a city of 25,000 located in the neighborhood of the steel mill, while the mill itself has a consumption estimated at 250,000,000 gal.

CLASSIFICATION OF WATER REQUIREMENTS

The water supplies of a steel mill may be roughly divided into three classes: In the first comes condenser-water circulation, a requirement familiar to all mechanical engineers. Next may be classified high-pressure water circulation for such purposes

as hydraulic machinery, testing steel tubing, etc. The volume of this water is not very large, but its handling requires a good deal of engineering knowledge. Thirdly, and probably the largest requirement of all, is that of cooling water for various purposes. Large amounts of this water are used in the blast-furnace plant for cooling the tuyeres, in the rolling mills for cooling beds, etc. This is usually referred to as service water.

In order to obtain an idea of the distribution of all this water an investigation was made of three large mills: one in the Pittsburgh district (name withheld at the request of the company); the second in the Cleveland district (Corrigan-McKinney Steel Co.); and the third in the Youngstown district (Republic Iron and Steel Co.). The method used was to list all the equipment dealing with water supplies and to indicate its actual output, with such additional information as may help to give an idea of the volume of water handled and its distribution.

This is believed to be the first time that complete statistical information as to water distribution in big mills has been published and data are given showing the number, kind, and capacities of the various pumps.

On the whole the investigation has shown that water is handled in steel mills with fair efficiency and economy in so far as the power necessary to convey it from intake to destination is concerned. There is little doubt, however, that considerable improvement can be made and some mills are now engaged in changes in their methods of water supply. This is said to be the case, for example, with the mill at Warren, formerly of the Trumbull Steel Co., now of the Republic Iron and Steel Co. Whether or not there is a waste of water it is difficult to say. Unquestionably in plants where water is scarce as, for example, at Donora, an effort is made to preserve the water. This was the situation in the former Forged Wheel Company's plant at Butler, Pa., and very serious attention was paid to this problem when the plant was taken over by the Columbia Steel Co. and converted into a continuous strip sheet mill. There is unquestionably an interesting problem here for mechanical engineers.

Mill in Pittsburgh District

This mill consists really of two plants—the North and the South—which initially were a considerable distance apart, and served by two railroad stations. Since their foundation, however, both mills have grown to such an extent that they have practically merged, and, as a matter of fact, it is expected that before the end of the year they will be within the same fence. At present the water supplies of the two mills are independent of each other, but the mains are so close together that there would be no trouble in interconnecting them should this prove to be necessary.

As in other mills the condenser water, high-pressure water, and the service supply are maintained substantially independent. (By service water is meant water used for all purposes, except condensers, where low pressure will serve.)

Special attention is called to Table 1 and the following statistical data for the year 1927 which indicate not only the truly enormous volume of water handled but also distribution among the various services. Water used for condenser service is so designated, and where possible the method of cleaning the water is indicated.

TABLE 1 WATER REQUIREMENTS OF A PITTSBURGH STEEL MILL (NORTH AND SOUTH MILLS COMBINED) FOR THE YEAR 1927, SHOWING DISTRIBUTION AMONG VARIOUS SERVICES

	Gal. per year
Electric power plant	2,267,428,000
Hydraulic power	1,109,811,000
Blowing-engine condensers	3,429,580,000
By-product coke ovens	2,786,761,000
Blast furnaces	11,000,000,000
Open-hearth furnaces	4,100,000,000
Blooming mill	2,300,000,000
Tube mills	2,000,000,000
Seamless tube mill	2,000,000,000
Miscellaneous	1,258,956,000
TOTAL	32,252,536,000

List of Pumps Used at Pittsburgh Steel Mill–South Mill

Condenser Circulating Pumps—South Mill Power House Intake

Two motor driven pumps with capacity of 40,000,000 g.p.d., each, with revolving screens.

One pump with capacity of 60,000,000 g.p.d., recirculated, or 33,000,000 g.p.d. prime. (This same pump listed under Service Water, South Mill.)

Normal demand for surface condensers is 100,000,000 g.p.d. with a head of 29 ft.

High-Pressure

In the tube mill for testing pipe, three motor driven triplex pumps, each having a capacity of 750,000 g.p.d. and one space pump; head, 2760 ft.

In the seamless-tube mill, for testing pipe, two pumps, each having a capacity of 432,000 g.p.d.; head, 2760 ft. The actual use amounts to 144,000 g.p.d.

For pressing tin-plate scrap, one pump, 4600-ft. head.

For hydraulic power, two steam driven plunger pumps, capacity 2,000,000 g.p.d. each, with flywheel engines; one steam turbine driven pump, capacity 2,000,000 g.p.d. Two pumps are in use, one is a spare. The head pumped against is 1380 ft. Total water pumped in 1927 was 537,245,000 gal.

Service Water for South Mills

River pump, ice breaker station; two motor driven pumps, capacity 12,000,000 g.p.d. each, no screens. Used in emergencies.

Power house intake, one motor driven pump, 33,000,000 g.p.d.; one turbine driven pump, 60,000,000 g.p.d. recirculating, 33,000,000 g.p.d. service; 60-ft. head; revolving screens.

Circulating pumps, boiler-house pump station, two steam driven duplex plunger pumps, capacity, 1,500,000 g.p.d. each; one motor driven centrifugal pump, 3,000,000 g.p.d.; 200-ft. head.

Cold mill, three motor driven pumps, 10,000,000 g.p.d. each; one spare.

Hot mill, No. 3 condenser, one motor driven pump, 5,000,000 g.p.d.

Rod mills; for circulating water for condenser one motor driven pump, 6,000,000 g.p.d.; for water for scaling rods, two pumps, 3,000,000 g.p.d. capacity each; one spare.

Use of Water in South Mill During 1927

	Gallons
Rod mills	3,000,000,000
Tin-plate mill	4,000,000,000
Miscellaneous	748,362,000
Total	7,748,362,000

North Mills and Tube-Mill Service Water Supply and Consumption

River Pump Houses, Central Pump House

Six vertical motor driven pumps, 12,000,000 g.p.d. each, and one vertical motor driven pump, 14,000,000 g.p.d.; stationary screens.

North Mill Pump House

Two steam turbine driven pumps, 30,000,000 g.p.d. each; revolving screens.

Recirculating Pump House

Two horizontal motor driven pumps, 20,000,000 g.p.d. each; no screens.

The Corrigan-McKinney Steel Co.

Apart from the fact that this is probably the only big steel company in the United States entirely owned by three women, widows of the founder of the company and its two successive presidents, the company is an interesting one in several ways. It started as a blast-furnace plant selling pig iron on the open market. In the early days of the World War it was converted into a steel mill and has now fourteen large open-hearth furnaces. Its fabricating department has never been developed to the extent to which all other large mills in this country are developed. It has a blooming mill capable of rolling all the ingots produced, but the only finishing mills are devoted to the manufacture of merchant-mill products and only a comparatively small amount

of the steel made is converted into the finished product. The rest is sold in the form of rolling billets, forging billets, and similar semi-finished products. Because of this, the water problem, in so far as distribution is concerned, is comparatively simple and the equipment used does not represent the same variety as that of the Pittsburgh mill previously described.

PUMPS USED AT CORRIGAN-MCKINNEY STEEL CO., CLEVELAND, OHIO, MAIN POWER STATION

Condenser Pumps

For two 7500-kw. turbo-generators, there are two duplicate units each consisting of a centrifugal pump, 16,000 g.p.m., 24-ft. head, driven by a 140-hp. steam turbine.

For one 2500-kw. mixed-pressure turbo-generator taking steam from blowing engines and auxiliaries, the pump is same as above except that condenser requires only 12,500 g.p.m.

For one 10,000-kw. turbo-generator, one centrifugal pump, 19,000 g.p.m., 25-ft. head, driven by a 150-hp. steam turbine.

For blowing engines of furnaces Nos. 1 and 2, one single-stage, motor driven pump, 18-in. suction and discharge, serving one 66 in. × 48 in. barometric condenser; and three single-stage, motor driven centrifugal pumps, 3000 g.p.m. capacity each.

WEST-SIDE STATION

WATER SUPPLY PUMPS (1)

Main Power Station

Two single-stage centrifugal pumps, 5000 g.p.m. each driven by 230-hp. steam turbine.

Two single-stage centrifugal pumps, 5000 g.p.m. each, driven by 235-hp. motor.

One single-stage centrifugal pump, 10,000 g.p.m., 150-ft. head, driven by 500-hp. motor.

One turbine driven two-stage centrifugal pump, 1500 g.p.m. used for washing and not directly connected to the water system.

WATER SUPPLY PUMPS (2)

Main Power Station

One turbine driven single-stage centrifugal pump, 5000 g.p.m., 140-ft. head, used for emergency service.

EAST-SIDE STATION

WATER SUPPLY PUMPS (3)

River Pump House

Five single-stage centrifugal pumps, 5000 g.p.m., driven by 235-hp. motors.

One single-stage centrifugal pump, 10,000 g.p.m., 150-ft. head, driven by 500-hp. motor.

POWER PUMPS

Three duplex steam driven plunger pumps, 1000 g.p.m., working at a pressure of 550 lb. per sq. in.

The following figures for February, 1928, give an idea of the water consumption even in a mill of this kind, where, as stated previously, the demand because of lack of finishing facilities is comparatively moderate:

	Gallons
High pressure	22,919,000
Steel plant	917,014,000
Main power station	702,105,000
Blast furnaces	1,746,619,000
Condensers	1,447,505,000

REPUBLIC IRON AND STEEL CO.

This is one of the companies which has to contend with unsatisfactory natural-water conditions. The supply is likewise insufficient. In addition to the Republic mill there is the old Prior mill, now the Western mill of the Youngstown Sheet & Tube Co; the huge Campbell mill of the same company; the Carnegie Steel Co. plant; the plant of the Sharon Steel Hoop Co.; and a considerable and growing number of fabricating mills. All of these require water. The result is that the conditions are not what they might be as has been mentioned already. The temperature of the cooling water in the reservoir in hot months goes up as high as 100 deg. fahr. and even with a new reservoir it will be probably around 85 deg. fahr. It is really quite a tribute to American steel-mill engineering that operations are being carried on on such an enormous scale under such forbidding conditions. This means, of course, a heavier volume of water used as is reflected in the large number and great capacity of the pumps listed in Table 2. Data of the total yearly water requirements are not available.

TABLE 2 LIST OF PUMPS WITH SIZES, CAPACITIES, AND TYPE OF DRIVE FOR VARIOUS SERVICES AT THE REPUBLIC IRON AND STEEL CO., YOUNGSTOWN, OHIO

SERVICE PUMPS

Size	Capacity, million gal. per 24 hr.	Type of drive
25 × 24 × 24 in.	5.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
24 × 18 × 18 in.	3.0	Steam, reciprocating
20-in. centrifugal	20.0	Steam turbine
25 × 24 × 24 in.	5.0	Steam, reciprocating
20-in. centrifugal[1]	20.0	Steam turbine
24-in. centrifugal	20.0	Steam turbine
18-in. centrifugal	11.5	Motor
18-in. centrifugal	11.5	Motor
12 × 18 × 19 × 16 in.[2]	2.14	Steam, reciprocating
12 × 18 × 19 × 16 in.[2]	2.14	Steam, reciprocating
12 × 18 × 19 × 16 in.[2]	2.14	Steam, reciprocating
14 × 25 × 21 × 18 in.[2]	2.5	Steam, reciprocating
10-in. vertical centrifugal[3]	4.03	Motor
10-in. vertical centrifugal[3]	4.03	Motor
10-in. vertical centrifugal[3]	4.03	Motor
10-in. centrifugal	4.03	Motor
10-in. centrifugal	4.03	Motor
14-in. 2-stage centrifugal	7.78	Motor
14-in. 2-stage centrifugal	7.78	Motor
14-in. 2-stage centrifugal	7.78	Motor
14-in. 2-stage centrifugal	7.78	Motor
14-in. 2-stage centrifugal	7.78	Motor
14-in. 2-stage centrifugal	7.78	Motor
8-in. centrifugal	2.16	Motor
10-in. centrifugal	3.60	Motor
12-in. centrifugal	0.72	Motor
20-in. centrifugal[4]	20.0	Steam turbine[4]
14-in. centrifugal	10.0	Motor
14-in. centrifugal	10.0	Motor
14-in. centrifugal	10.0	Motor
24-in. centrifugal	20.0	Steam turbine
12 × 18 × 19 × 16 in.[5]	2.14	Steam, reciprocating
12 × 18 × 19 × 16 in.[5]	2.14	Steam, reciprocating
12 × 18 × 19 × 16 in.[5]	2.14	Steam, reciprocating
14 × 25 × 21 × 18 in.[5]	2.5	Steam, reciprocating
18-in. centrifugal[6]	11.5	Motor
10-in. vertical centrifugal[7]	4.03	Motor
10-in. vertical centrifugal[7]	4.03	Motor
10-in. vertical centrifugal[7]	4.03	Motor
10-in. centrifugal	2.88	Motor
10-in. centrifugal	3.9	Motor

[1] Service *or* condenser water pumped by this pump.
[2] For service *and* condenser; both at the same time.
[3] For power-house condensers and service; both at the same time.
[4] Service, *or* condenser water handled by this pump
[5] For service *and* condenser; both at same time.
[6] Serves continuous mill engine condenser only.
[7] For power-house condensers *and* service; both at same time.

BENEFITS from the works projected by the Mahoning Valley Sanitary District for a new water supply for Youngstown and Niles, Ohio, and the division of the benefits between the two cities have been determined by a board of appraisers and its findings have been confirmed by the court of jurisdiction. This action gives the directors of the district authority to finance the project by levying assessments and issuing bonds.

The appraisers set out a total benefit of $5 per capita per year for a 25-year period, 1930 to 1955, corresponding approximately with the period of payment of the assessment upon the two cities. This per capita rate was applied to the estimated total populations of the two cities for the period mentioned. The actual annual benefit so calculated was brought back to 1930 value, using an interest rate of 4 per cent compounded and resulting in a total benefit for the period mentioned of $21,534,000. This total benefit is comparable to the estimated cost of execution of the "official plan," $9,150,000. The latter sum does not include interest charges during construction.—*Engineering News-Record*, July 5, 1928, p. 29.

Test Code for Water-Cooling Equipment

Tentative Draft of a Code in the Series of Twenty-Two, Formulated by the A.S.M.E. Committee on Power Test Codes

The Main Committee on Power Test Codes takes pleasure in presenting to the Members of the Society the Test Code for Water-Cooling Equipment for criticism and comment. The Individual Committee which developed this draft of the code consists of Messrs. G. A. Orrok, Chairman, P. E. Reynolds, Secretary, C. H. Baker, R. N. Ehrhart, J. J. Mullan, H. B. Reynolds, and M. C. Stuart. It is believed that in its present form this Code meets the needs of all groups which from time to time have a part in the making of acceptance tests of this type of apparatus.

In 1918 the Committee on Power Test Codes was organized by the Council of the A.S.M.E. to revise and enlarge the Power Test Codes of the Society published in 1915. This Committee consists of a Main Committee of 25 members under the Chairmanship of Fred R. Low, and 20 individual committees of specialists who are drafting test codes for the various prime movers and the other auxiliary and related apparatus which constitute power-plant equipment.

The Individual Committee, the Main Committee, and the Society will welcome suggestions and corrections, or additions to this draft from those who are especially interested in the manufacture, use, and testing of water-cooling equipment. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Introduction

1 This Code is designed to be used when conducting tests of water-cooling equipment. There is a large variety of apparatus employed for this purpose, but the following Code applies only to the equipment or methods wherein the major cooling is done by evaporation and which are in general use for the cooling of a comparatively large amount of water required for power or industrial purposes. This equipment is as follows:

1 Chimney or Natural-Draft Cooling Towers
2 Forced-Draft Cooling Towers
3 Atmospheric or Wind Towers
4 Spray Installations
5 Natural and Artificial Ponds and Reservoirs.

2 Before proceeding with a test covering the above apparatus, the "Code on General Instructions," "Code on Definitions and Values," and "Instrument and Apparatus" should be carefully studied and followed in all matters relating to the particular test which is to be conducted.

Object

3 In making a test several objects may be in mind as discussed in the chapter of the "Code on General Instructions," but usually tests on water-cooling equipment are conducted:

1 To determine the fulfilment of the manufacturer's guarantee
2 To determine the performance of the apparatus in part or as a whole from the standpoint of efficiency of operation or to establish data for scientific use
3 To obtain data to be used for the calculation of water-cooling effect available for power or for other purposes.

4 The first two objects merely entail the recording of the desired data with the apparatus in operation under the specified conditions.

5 The third object relates principally to investigations covering the cooling effected by surface evaporation in ponds, lakes, or reservoirs under various atmospheric conditions, etc. Such an investigation may be complicated where there is an auxiliary cooling apparatus such as a spray system installed over the pond or reservoir in question, and involves the recording of extensive data covering the magnitude of evaporation, rainfall, run-off, drainage area, etc. A considerable amount of this information may frequently be obtained from Government publications.

6 Water-cooling equipment is usually guaranteed to cool a definite quantity of water through a definite temperature range with definite temperatures of air and humidities, and with some types of apparatus it is necessary to specify wind velocities. As definite guaranteed atmospheric conditions are practically impossible to duplicate, it is desirable that curves be furnished to show the guaranteed performance of the apparatus over a considerable range of atmospheric conditions when cooling varying quantities of water. A statement is also frequently made covering the amount of make-up water which will be required and the power consumed by auxiliaries.

Instruments and Apparatus

7 The instruments and apparatus required for a test of water-cooling equipment consist of the following:

(*a*) Thermometers for recording water and air temperatures. Thermometers used for water temperatures should be graduated in half-degrees and have a range from 32 deg. to 212 deg. fahr. Thermometers used for air temperatures should be graduated in half-degrees with a range from 0 to 150 deg. fahr.
(*b*) Draft or pressure gages graduated in hundredths of inches of water for measuring air pressures
(*c*) Tanks, and platform scales or some calibrated measuring device or apparatus for the accurate weighing or measuring of water
(*d*) Anemometers for measuring flow of air and wind velocity
(*e*) Psychrometer for determining humidity and wet-bulb temperature
(*f*) Barometer for measuring atmospheric pressure
(*g*) Appliances for the testing of auxiliary pumps, engines, motors, etc., such as steam indicators electrical instruments, speed indicators, tachometers, etc.

8 General directions for the application, use, and calibration of these instruments and apparatus, and information regarding their range and accuracy are given in "Instruments and Apparatus." To measure the quantities of water cooled the same kind of apparatus may be employed as that used in pump, engine, or water-wheel tests, such as weirs, nozzles, pitot tubes, etc. (See "Test Code for Reciprocating Steam-Driven Displacement Pumps" and "Test Code for Hydraulic Power Plants and Their Equipment.") If the water is used as circulating water in a condenser, the amount may be calculated from the temperature rise and the amount and condition of the steam condensed. (See "Test Code for Condensing Apparatus.")

LOCATION OF INSTRUMENTS AND APPARATUS, AND GENERAL PRECAUTIONS

9 (1) Thermometers showing water temperatures should be located only in positions where the water has been thoroughly mixed and stratified flow eliminated. (See "Test Code for Condensing Apparatus" under "Circulating Water Temperatures.")

(2) To obtain wet- and dry-bulb air temperatures for determining humidity, a sling psychrometer or other approved mechanically ventilated thermometers should be used.

10 It is important that the muslin covering for the wet bulb be kept in good condition. The evaporation of water from the muslin always leaves in its meshes a small quantity of solid material which sooner or later somewhat stiffens the muslin so that it does not readily take up water. This will be the case if the muslin does not readily become wet after being dipped in water. On this account it is desirable to use as pure water as possible, and also to renew the muslin from time to time. New muslin should always be washed to remove sizing, etc., before being used. If desired, knitted wet-bulb jackets can be obtained from thermometer dealers.

11 To make an observation, the wet bulb is thoroughly saturated with water by dipping it into a small cup or wide-mouth bottle. The thermometers are then whirled rapidly for fifteen or twenty seconds, stopped, and quickly read, the wet bulb first. This reading is kept in mind, the psychrometer immediately whirled again, and a second reading taken. This is repeated three or four times, or more, if necessary, until at least two successive readings of the wet bulb are found to agree very closely, thereby showing that it has reached its lowest temperature. A minute or more is generally required to secure the correct temperature.

12 When the air temperature is near the freezing point, it very often happens that the temperature of the wet bulb will fall several degrees below the freezing point, but the water will still remain in a liquid state. No error results from this, provided the minimum temperature is reached. If, however, as frequently happens, the water suddenly freezes, a large amount of heat is liberated, and the temperature of the wet bulb immediately becomes 32 deg. In such cases it is necessary to continue the whirling until the ice-covered bulb has reached a minimum temperature.

13 The psychrometer should be whirled in the shade of a building or tree, or, as may sometimes be necessary, under an umbrella. In all cases there should be perfectly free circulation of the air, and the observer should face the wind, whirling the psychrometer in front of his body. It is a good plan, while whirling, to step back and forth a few steps to further prevent the presence of the observer's body from giving rise to erroneous observations.

14 Humidity is determined by psychrometric tables using wet- and dry-bulb temperatures.

15 (3) Thermometers for measuring temperatures of air should be located in a strong current of air, shielded from the direct rays of the sun or radiation from any adjacent body.

16 The determination of air temperatures and humidities at the discharge of cooling towers is extremely difficult on account of particles of water which are mechanically entrained in the air and also due to eddy currents which are frequently induced by the comparatively large discharge openings. The thermometers used at the discharge of a cooling tower should be protected by separators to remove the mechanically entrained water and also to shield them from extraneous wind or eddy currents.

17 Results of calculations based on air temperatures and humidities obtained at the discharge of cooling towers, unless unusual precautions are taken, must be used with caution.

18 Air velocities and quantities may be measured by means of an anemometer by dividing a cross-section of the air current into comparatively small areas and determining the air velocity in each small area. The velocities thus obtained are then averaged to determine the average velocity over the entire cross-section. This method of determining air quantities is subject to many difficulties in its operation, and the results obtained, unless great care is taken to guard against eddy currents, should be considered as approximate only.

PREPARATION

19 Before proceeding with the test of any water-cooling equipment the "Code on General Instructions" should be carefully studied. The dimensions and physical conditions of the equipment should be ascertained. If the cooling tower is to be tested, the filling of the tower should be examined to see that it is in good condition. The water-distributing system should also be examined to see that the water is distributed over the filling as uniformly as the design will permit. If the tower is of the forced-draft type, care must be taken to see that there are no openings or cracks in the tower casing through which an appreciable amount of air might escape. If a test of a spray installation is made, the spray heads should be thoroughly cleaned before proceeding with the test.

OPERATING CONDITIONS

20 The operating conditions such as speed of fans, water pressure at sprays, amount and temperature of water to be cooled, should be determined previous to beginning the main trial, and these conditions should prevail throughout the test. As it is frequently impossible to obtain just the weather conditions as to temperature and humidity desired, corrections should be agreed upon covering discrepancy between actual conditions and conditions specified for the test.

CALCULATION OF RESULTS

21 *Heat Balance.* Since the heat given up by the water must equal that absorbed by the air (radiation being considered negligible), the heat balance as calculated from the data obtained must show a practical agreement between these quantities. Also the amount of air required (Item 76) as estimated from the heat balance should agree with the amount of air entering the tower as measured (Items 64 and 77).

Let

W = pounds of water entering tower per minute calculated from Item 44

A = pounds of dry air entering tower per minute calculated from Items 36, 37, 38, and 39

t_{w1} = temperature of water entering tower (Item 45)

t_{w2} = temperature of water leaving tower (Item 46)

t_{a1} = temperature of air entering tower (Item 37)

t_{a2} = temperature of air leaving tower (Item 66)

S = specific heat of air

M_1 = pounds of vapor contained per pound of dry air entering tower, calculated from Items 36, 37, 38, 39, and psychrometric tables

M_2 = pounds of vapor contained per pound of dry air leaving tower, calculated from Items 36, 66, 67, 68, and psychrometric tables

H_{m1} = heat content of M_1 lb. of vapor at temperature t_{a1}; calculated from Items 36, 37, 38, 39, and steam, and psychrometric tables

H_{m2} = heat content of M_2 lb. of vapor at temperature t_{a1}; calculated from Items 36, 66, 67, 68, and steam and psychrometric tables

H_{w1} = heat content of cooling water entering tower per pound of dry air entering tower

H_{w2} = heat content of cooling water leaving tower per pound of dry air entering tower

H_{a1} = heat content of moist air per pound of dry air entering tower

H_{a2} = heat content of moist air per pound of dry air leaving tower.

NOTE: All heat contents calculated above 32 deg. fahr.

Then

$$H_{w1} - H_{w2} = H_{a2} - H_{a1}$$

$$H_{w1} = \frac{W}{A}(t_{w1} - 32) \text{ and } H_{w2} = \frac{W}{A}(t_{w2} - 32) - (M_2 - M_1)(t_{w2} - 32)$$

$$H_{w1} - H_{w2} = \frac{W}{A}(t_{w1} - t_{w2}) + (M_2 - M_1)(t_{w2} - 32)$$

$$H_{a1} = (t_{a1} - 32)\,S + H_{m1}$$

$$H_{a2} = (t_{a2} - 32)\,S + H_{m2}$$

$$H_{a2} - H_{a1} = S(t_{a2} - t_{a1}) + (H_{m2} - H_{m1})$$

$$\frac{W}{A}(t_{w1} - t_{w2}) + (M_2 - M_1)(t_{w2} - 32) = S(t_{a2} - t_{a1}) + (H_{m2} - H_{m1})$$

$$A = \frac{W(t_{w1} - t_{w2})}{S(t_{a2} - t_{a1}) + (H_{m2} - H_{m1}) - (M_2 - M_1)(t_{w2} - 32)}$$

DATA AND RESULTS

22 For complete tests it is recommended that data be recorded using the following table, items being added or omitted as required by the particular test. Sketches showing details and arrangement of the apparatus not clearly covered by descriptive items should be attached to the data sheets.

DATA AND RESULTS—TEST CODE FOR WATER-COOLING EQUIPMENT

General Information

(1) Date of report
(2) Place of test
(3) Cooling water for
(4) Object of test
(5) Test conducted by
(6) Name of manufacturer
(7) Guarantee

Description and Dimensions

Cooling Tower:

(8) Type (forced draft or natural)
(9) Shape and size
(10) Size and depth of reservoir (if any)
(11) Type of water distributor
(12) Location of water distributor
(13) Type of filling
(14) Arrangement and depth of filling
(15) Material of filling
(16) Distance from center of distributor to water level in reservoir
(17) Number and size of forced-draft fans (if any)
(18) Type of fans and how driven
(19) Location of fans
(20) Special features

Natural Cooling or Spray Reservoir:

(21) Type of sprays (if any)
(22) Number and size of sprays
(23) Arrangement of sprays
(24) Distance between sprays
(25) Height of sprays above water level in reservoir
(26) Size of reservoir (at water line) ..... ft.
(27) Area of reservoir ..... sq. ft.
(28) Average depth of reservoir ..... ft.
(29) Capacity of reservoir ..... cu. ft.
(30) Baffle arrangement in reservoir (if any)
(31) Location of inlet and outlet from reservoir
(32) Source of make-up water
(33) Special features

Date and Duration

(34) Date of test
(35) Duration of test ..... hr.

Average Atmospheric Conditions

(36) Barometer (corrected for temperature) ..... in. Hg
(37) Temperature of atmosphere ..... deg. fahr.
(38) Temperature of wet-bulb thermometer ..... deg. fahr.
(39) Relative humidity ..... per cent
(40) Direction of wind
(41) Velocity of wind ..... m.p.h.
(42) Weather (clear or cloudy)
(43) Rainfall during test (if any) ..... in.

Test Data

(44) Amount of water cooled ..... g.p.m.
(45) Temperature of water entering sprays, tower or reservoir ..... deg. fahr.
(46) Temperature of water leaving reservoir ..... deg. fahr.
(47) Make-up water used ..... g.p.m.
(48) Temperature of make-up water ..... deg. fahr.
(49) Level of water in reservoir at start of test ..... ft.
(50) Level of water in reservoir at end of test ..... ft.
(51) [1]Temperature of water in reservoir at start of test ..... deg. fahr.
(52) [1]Temperature of water in reservoir at end of test ..... deg. fahr.
(53) Loss of water in per cent of total circulated ..... per cent
(54) Overflow from reservoir (if any) ..... g.p.m.
(55) Area drained by reservoir ..... acres
(56) Average run-off ..... per cent of rainfall
(57) Reservoir leakage
(58) Pressure of water at center line of spray or distributor ..... lb. per sq. in.
(59) Pressure of water at entrance of tower or spray system ..... lb. per sq. in.
(60) Total water head required for operation ..... ft.

Cooling Tower:

(61) Speed of fans (if any) ..... r.p.m.
(62) Power required to drive fans ..... hp.
(63) Steam required to drive fans ..... lb. per hr.
(64) Air handled ..... cu. ft. per min.
(65) Air pressure or draft in base of tower ..... in. water
(66) Temperature of air leaving tower ..... deg. fahr.
(67) Temperature of wet-bulb air leaving tower ..... deg. fahr.
(68) Relative humidity of air leaving tower ..... deg. fahr.
(69) Air cooled per square foot of cross-section of tower ..... g.p.m.
(70) Air per square foot of cross-section of tower ..... cu. ft. per min.

Heat Balance:

(71) Water entering tower per pound of dry air per minute (calculated from Items 44, 63, 37, and 39) ..... lb.
(72) Vapor per pound of dry air entering tower (calculated from Items 36, 37, 38, 39, and psychrometric table) ..... lb.
(73) Vapor per pound of dry air leaving tower (calculated from Items 36, 66, 67, 68, and psychrometric table) ..... lb.
(74) Heat given up per pound of water entering tower ..... B.t.u.
(75) Heat absorbed per pound of dry air entering tower ..... B.t.u.
(76) Air at temperature (Item 37) and humidity (Item 39) required as calculated from heat-balance equation ..... cu. ft. per min.
(77) Air at temperature (Item 37) and humidity (Item 39) as determined from actual air measurement ..... cu. ft. per min.

[1] NOTE: It is advisable to measure the temperature of water in a reservoir or pond at different places and depths to determine if possible the path of circulation and how much of the pool's volume is used effectively.

The Influence of Elasticity on Gear-Tooth Loads

Progress Report No. 12 of the A.S.M.E. Special Research Committee on Strength of Gear Teeth[1]

THIS progress report is the last of a series of nine reports (Progress Reports Nos. 4 to 12) discussing a possible method of analysis of the test results obtained on the Lewis gear-testing machine, using the various equations developed in the previous progress reports to test their consistency, and deals with the runs which were made with grades of different materials.

IX Load Conditions on Trains of Gears

Thus far we have attempted to analyze the load conditions of a single pair of gears only. On the testing machine it has been apparent that the back, or master gears were subjected to heavier loads than the test pair. This same condition is also often apparent on the second pair of a double-reduction gear set and the second pair of a train of gears. The conditions which exist on such trains are so involved that anything like a complete analysis would be extremely complex. For the present, therefore, only a general approximation will be attempted.

Where a gear train with two tooth meshes is involved, and the power is applied smoothly to the first driving gear, it should be apparent that due to elasticity and errors in the tooth form and spacing, the power will be applied to the second mesh in impulses of greater or less intensity. The timing of these impulses may be such that at times the resultant load on the teeth at the second mesh may be more or less than if they were operating as a single pair. The probability is that some time during the cycle the maximum impulse from the first mesh will be added to the acceleration impulse of the second mesh. This would occur whether the acceleration of the first mesh synchronized with that of the second mesh, or the impact of the first mesh synchronized with the acceleration of the second mesh because the influence of either condition would probably be practically the same.

All of the acceleration or impact impulse of the first mesh, however, would not be transmitted to the second mesh because of the elasticity of the gear blank and its mounting and also because of the work absorbed in internal friction at the first mesh, etc. As a rough approximation for tentative use, we shall assume that 25 per cent of the original impulse is dissipated so that 75 per cent of it will be transmitted to the second mesh when the impulse is transmitted through an intermediate gear.

If a double-reduction gear train is involved, the elasticity of the shaft connecting the driven gear of the first mesh with the driving gear of the second mesh would act to reduce the amount of the impulse transmitted from the first mesh still more. This condition might be analyzed in a very similar manner to that used in Progress Report No. 7 to analyze the influence of the rotating masses mounted on the pinion shaft.

The effective mass of the intermediate gear of a train is another uncertain factor. Any tendency of this gear to retard because of conditions at the second mesh is resisted by the inertia of the effective mass at the first mesh, thus making the effective mass of the intermediate gear at the second mesh greater than it otherwise would be. In some ways it would seem as though this increased mass of the intermediate gear would influence both the first and second meshes more or less equally, but experience seems to indicate that its primary influence is evident at the second mesh. The cumulative effect seems to be carried along in the direction of the flow of power.

In order to attempt to obtain some possible light on these conditions, we shall attempt to analyze the results of some tests which were made at Stanford University in 1924 by Lloyd J. Franklin and Charles H. Smith under the supervision of Prof. Guido H. Marx. In these tests, the test gears were the end gears of a train. The results of these tests on gears of varying degrees of accuracy are given in a paper presented at the 1924 Annual Meeting of The American Society of Mechanical Engineers.

The test gears were driven from a motor through a chain drive and a pair of change gears, while the load was applied by a friction brake attached to the shaft of the driven test gear. The errors in the change gears were probably about 0.002 in., and this error was probably increased in some of the tests because the log reports the large steel change gear as badly abraded on run C-10 and as practically useless after run C-11. As a rough approximation we shall assume the additional acceleration load on the test gears on this machine, because of the chain and change gear drive, to be equal to 75 per cent of the acceleration load on the test gears with an error of 0.002 in., and analyze these test results in the same manner as we have analyzed the previous tests.

These test gears were of semi-steel, 10 D.P., 60 teeth, $14^1/_2$ deg. pressure angle, with $1^1/_{16}$ in. face. We shall examine first the tests of the gears with errors of 0.002 in.

First we must assume some value for the effective mass. The effective mass of one of the test gears alone at the pitch line is about 0.125. The driver is connected to the shaft carrying the driven change gear so that the actual mass effect at its pitch line will be considerably greater. Also this mass effect will vary with the speed because of the influence of the elasticity of the connecting shaft. The driven test gear is attached to the shaft carrying the friction brake so that the mass effect at the pitch line of this gear will also be greater and will vary with the speed. The tests were run at approximately 1000, 1500, and 2000 ft. per min. pitch-line velocity. We shall therefore assume the following effective masses:

---

[1] The personnel of the A.S.M.E. Special Research Committee on the Strength of Gear Teeth is as follows:

Wilfred Lewis, *Chairman*, President, Tabor Manufacturing Company, 6225 Tacony Street, Philadelphia, Pa.

Carl G. Barth, 420 Whitney Avenue, New Haven, Conn.

Earle Buckingham, Professor, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Ralph E. Flanders, Manager, Jones & Lamson Machine Company, Springfield, Vt.

Arthur M. Greene, Jr., Dean, School of Engineering, Princeton University, Princeton, N. J.

Clarence W. Ham, Professor of Machine Design, University of Illinois, 115 Transportation Building, Urbana, Ill.

Charles H. Logue, *Secretary*, Consulting Engineer, 123 Clarke Street, Syracuse, N. Y.

Fred E. McMullen, Manager Cutter Department, The Gleason Works, Rochester, N. Y.

Edward W. Miller, Chief Engineer, Fellows Gear Shaper Company, Springfield, Vt.

Ernest Wildhaber, 1110 East 21st Street, Brooklyn, N. Y.

V	m
1000	0.400
1500	0.300
2000	0.250

The other values required are as follows:

y_1 and y_2	0.113
z_1 and z_2	0.10648
E_1 and E_2	15,000,000
R_1 and R_2	3.000
p	0.3142
e'	0.002

$$d_t = f\left(\frac{E_1 z_1 + E_2 z_2}{E_1 z_1 \times E_2 z_2}\right) = 0.00000125 f \qquad [I\text{-}26]$$

$$f_a = \frac{f_1 \times f_2}{f_1 + f_2} \qquad [II\text{-}9]$$

$$f_1 = 0.0025\, p \left(\frac{R_1 + R_2}{R_1 \times R_2}\right)^2 m V^2 = 0.00035 m V^2 \qquad [II\text{-}7]$$

$$f_2 = f\left(\frac{e'}{d_t} + 1\right) = 1600 + f \qquad [II\text{-}8]$$

The foregoing equations give the acceleration load for a single pair of gears. To calculate the amount of separation and the impact load we shall use a value 75 per cent greater than the calculated acceleration load on this gear train. This increased acceleration load we shall call f'_a. Thus in this case

$$f'_a = 1.75\, f_a$$

$$k = \frac{f'_a}{f} e' - \left[\left(\frac{f'_a}{f}\right)^2 + 1\right]\frac{d_t}{2} \qquad [V\text{-}1]$$

$$F = f(1 + \sqrt{1 + 2k/d}) \qquad [III\text{-}8]$$

The log of this run together with the calculated values of F is given in Table 1. The static strength of the teeth is calculated by the Lewis formula using the values of the flexural strength as determined from test bars cut from the gears after the tests were completed as the value of the stress in the Lewis formula. These values are also tabulated in Table 1. Tests were also made by breaking a tooth out of the test gears which indicated that the static strength of these gear teeth was about 3200 lb., a value which is considerably higher than the calculated value. These last static tests were somewhat uncertain because of the spring of the apparatus under load. The probable static strength of these teeth may be between the two values, and possibly closer to 3200 than to the tabulated calculated values. As a basis of comparison, however, we shall use the calculated values.

With the exception of runs A-2 and A-3, the calculated impact loads are very consistent with each other. Their variation is much less than the variation in the tests of the samples cut from the test blanks. As regards runs A-2 and A-3, it is stated in the paper that it is thought these two values are too low because of failure to lubricate the friction brake with oil on the earlier runs as was done on all later runs, thus resulting in faulty operation of the friction brake.

With these two exceptions, the calculated impact loads varied from 10 to 30 per cent greater than the calculated static loads, which would tend to confirm the qualitative soundness of the deductions which have been made. The numeric accuracy of the calculated values is open to question because of the many uncertain factors for which arbitrary values have been assumed. The purpose of this analysis is primarily to test the consistency of the method, however, rather than to prove its actual accuracy.

We shall now examine the tests on gears with errors of 0.006 in. For this we have the same values as before except

e'	0.006
f_2	$4800 + f$

The log of this run with the calculated values as before is given in Table 2. The calculated values on the first three runs at the lower speed are considerably higher than those of the succeeding runs. The impact load values of the last six runs check very closely to each other and to those of the preceding series of tests.

We shall now examine the tests on the gears with errors of about 0.01 inch. For this we have the same values as before except that

e'	0.001
f_2	$800 + f$

The log of this run together with the calculated values as before is given in Table 3. The change gears on the machine were badly abraded during the last runs shown in Table 3 which probably accounts for the lower values here. Otherwise the calculated values here are very consistent with each other and with the values in the preceding tests.

It would appear from the general consistency of the results of the analysis of the data in the last five progress reports that the hypothesis developed in Progress Reports Nos. 4, 5, and 6 is reasonably reliable, although some refinement is possible and it is hoped to obtain more accurate numeric values as the results of further tests.

TABLE 1

Run No.	V	f	f_a	f'_a	F	Static strength
A-1	950	1710	77 2	135	2513	2190
A-2	955	1380	77 9	136	2185	2252
A-3	955	1370	77 9	136	2169	2221
B-1	1404	1520	168	294	2505	2041
B-2	1396	1690	167	291	2675	2466
B-3	1384	1810	159	279	2786	2337
C-2	1850	1320	271	475	2455	1938
C-3	1831	1390	267	467	2519	2232
C-4	1850	1320	271	475	2455	1790

TABLE 2

Run No.	V	f	f_a	f'_a	F	Static strength
A-5	960	1310	126	218	3553	2115
A-6	960	1240	126	218	3499	2282
A-7	955	1170	125	217	4010	2134
B-4	1448	720	212	357	2536	2109
B-5	1425	990	205	250	2791	1971
B-6	1425	990	205	350	2791	1836
C-5	1893	910	298	500	3038	2199
C-6	1920	420	304	507	2562	1974
C-7	1899	750	299	502	2881	1937

TABLE 3

Run No.	V	f	f_a	f'_a	F	Static strength
A-8	915	2420	113	205	2962	2164
A-9	930	2270	116	208	2828	2040
A-10	930	2050	116	208	2593	1979
B-8	1374	2270	186	278	2873	2298
B-9	1374	2360	186	278	2985	2222
B-11	1374	2320	186	278	2935	2183
C-8	1820	1620	259	351	2287	2313
C-9	1809	1720	257	349	2386	1944
C-11	1766	1970	251	343	2624	2214

High-Pressure Steam Boilers

IN THE article on High-Pressure Steam Boilers in the June issue of MECHANICAL ENGINEERING, the formula at the bottom of the first column on page 444 should read

$$\frac{E_t}{E_{32}} = 1 - \left(\frac{t - 32}{1700}\right)$$

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Flight by Human Power

GENERAL description of an ornithopter devised by the author, a Russian aviator. The machine has not yet been built, however. The author claims that the loading per square foot is so low that a speed of only 12 m.p.h. is required to lift the machine.

To gain height the wings must be flapped, but once height has been attained it is claimed that a man will be able to utilize the energy of the disturbed air and soar continuously, only flapping his wings to attain more speed. The dimensions of the machine are said to be small. (Capt. Victor Dibovsky, *Airways*, vol. 4, no. 10, June, 1928, pp. 363-364, 2 illustr., *d*)

ELECTRICAL ENGINEERING (See Steam Engineering: Electric Boilers and Steam Accumulators)

ENGINEERING MATERIALS

Borium as a Substitute for Diamonds

BORIUM (made by the Stoody Co., of Whittier, Calif.) is intended to be used as a substitute for diamonds in drilling. It is a manufactured product with a hardness between that of a sapphire and a diamond. Although it cannot be melted in the hottest part of the oxyacetylene flame, other metals such as iron and steel can be brazed or fused to it. It cannot be softened by any kind of heat treatment, but can be decomposed by the prolonged heat from an electric arc. It is insoluble in any single acid, hot or cold, and can neither be machined nor ground. The article describes how to set the borium in drilling bits and put metal around it. (*The Petroleum Times*, vol. 19, no. 483 (Old Series 1342), Apr. 14, 1928, p. 680, *d*)

Properties of Materials for Use at High Temperatures With Special Reference to Boilers for Superheated Steam

RECENT research has shown that the tensile strength of materials at high temperature obtained by the ordinary methods of testing at air temperature is misleading. It has also been found that at high temperature a stress much lower than the ultimate tensile stress will cause failure of any material if prolonged for some time. This is due to creep or flow of the material with time. (Compare, on the subject of creep, MECHANICAL ENGINEERING, vol. 47, no. 8, Aug., 1925, p. 664, and the next abstract.) Further it has been shown that for each temperature there is a stress below which the material will not fail or will last for many years. This stress has been called the "limiting-creep stress." There is considerable difference of opinion as to the method by which this limiting-creep stress should be determined. Two conditions are met with in design—(*a*) where no permanent deformation is admissible, and (*b*) where permanent deformation can be allowed, provided failure does not result.

There is probably a temperature where the maximum stress for both conditions is coincident, that is to say, where, if permanent deformation occurs, failure results. On the other hand, at a lower temperature permanent deformation can occur without failure. This is due to the fact that at such a temperature the material "strain-hardens" under stress and temperature, owing to creep or flow without appreciable softening, and the creep ultimately ceases, whereas at a higher temperature there is appreciable softening and flow continues.

The results expected from steels used for boiler and superheater tubes and superheater and steam drums are given in tables in the original article. These values indicate the extremely rapid decrease in the limiting-creep strength of boiler-tube shells as the temperature is raised above 400 deg. cent. (752 deg. fahr.). At a temperature of 525 deg. cent. (977 deg. fahr.) the actual working stress in the tubes may be equal to the limiting-creep stress. There is evidenced that failure by intercrystalline cracking may occur with boiler-tube steel at temperature of about 600 to 650 deg. cent. (1112 to 1202 deg. fahr.). Further this steel readily oxidizes in the presence of air at a temperature above 570 deg. cent. (1058 deg. fahr.). For working stresses and temperatures of the order of 800 lb. per sq. in., special materials have therefore to be employed, and the author mentions a series of alloy steels and an alloy of 70 per cent nickel with 30 per cent chromium. (Reginald Geo. Cyril Batson, *Engineering Conference*, 1928, *The Institution of Civil Engineers*, Group 2, paper no. 18, pp. 12-16, *g*)

Creep of Materials

THE author believes that creep takes place at all temperatures. Table 1 gives the probable stress ratios which produce the same rates of creep at 900 deg. fahr. and 700 deg. fahr. In the case of steam piping and stationary parts of a turbine the stress is practically proportional to the pressure. By using such ratios as those given in Table 1 the steam pressures which

TABLE 1 RATIO OF PERMISSIBLE STRESS TO PRESERVE THE SAME RATES OF CREEP AT 900 DEG. FAHR. AS AT 700 DEG. FAHR. FOR FORGED STEEL

Authority	Reference	Carbon, per cent	Limiting creep stress ratio $\frac{\text{900 deg. fahr.}}{\text{700 deg. fahr.}}$	Stress ratio for $\frac{\text{900 deg. fahr.}}{\text{700 deg. fahr.}}$ Strain 10^{-5} per hr.
National Physical Laboratory	Report No. 2	0.51	0.36	
	Report No. 1	0.24	0.37	
	Report No. 1	0.17	0.37	
R. G. C. Batson	Inst C. E., Engrg. Conference, 1928, Note, no. 18	0.23	0.356	
H. J. French and W. A. Tucker	Bur. Standards Technical Paper no. 296	0.24	0.327	0.408
A. Pomp and A. Dahman	Mitteilungen aus dem Kaiser-Wilhelm-Inst. für Eisenforschung, vol. IX (1927), p. 35	0.40	...	0.46
		0.23	...	0.39
		0.046	...	0.53

TABLE 2 COMBINATIONS OF PRESSURE AND TEMPERATURE WHICH GIVE THE SAME FACTOR OF SAFETY ON CREEP

Ratio $\frac{\text{Stress at 900 deg. fahr.}}{\text{Stress at 700 deg. fahr.}}$	Corresponding Pressures: 900 deg. fahr., lb. per sq. in.	Corresponding Pressures: 700 deg. fahr., lb. per sq. in.	Thermal gain with higher temperature conditions, per cent
0.45	350	778	2.8
0.40	350	875	2.3
0.35	350	1000	1.9
0.45	250	556	1.7
0.40	250	625	1.1
0.35	250	715	0.4

will produce the same rate of creep at 900 deg. fahr. and 700 deg. fahr. in a particular element of the plant of definite dimensions and materials can be estimated. Table 2 gives a series of corresponding temperature and pressure conditions.

Though knowledge of creep is not yet extensive or precise, the data used in the foregoing observations are probably accurate enough to justify the conclusion that with equal factors of safety the higher temperature condition will probably give the higher thermal efficiency. (Henry Lewis Guy, *Engineering Conference*, 1928, *The Institution of Civil Engineers*, Group 2, paper no. 20, pp. 20–26, *g*)

FOUNDRY

Lacquer Finish for Patterns

IT HAS been the experience of the Fellows Gear Shaper Co., Springfield Vt., that shellac does not provide an entirely satisfactory protective coating for patterns. Moisture from the molding sand penetrates the shellac, causing the grain of wood to become raised and the glued joints to start to open, as a result of which the pattern gets out of shape and will not produce a true casting. The same applies to core boxes.

After much experimenting and research work the company has adopted lacquer for all their standard patterns. In the recent flood which visited northern New England practically all the patterns and wood flasks were carried off by the water. Lacquer-covered patterns and wood plates went with the rest. Some of these patterns as well as some of the shellac-covered patterns were found scattered along the banks of the river for three miles. The glued joints of the shellac-covered patterns had either started to open or were all apart, and the shellacked wood plates were out of shape. Ninety per cent of all shellacked patterns had to be replaced before more castings could be made. The lacquered patterns were absolutely dry and the glued joints were good, even though some of them were in the water for three days. The lacquered wood plates were absolutely straight, showing that no moisture had penetrated the lacquer. Experiments seem to indicate that a brushing lacquer gives more satisfactory results than a spraying lacquer. Wax fillets, etc., should be shellacked over before applying the lacquer as the lacquer does not harden properly on the wax and the molding sand will stick to it. The first cost of finishing a new pattern with lacquer is more than the cost of finishing with shellac. However, several hundred castings can be made from a lacquer-finished pattern without any change in the smooth true shape of the castings purchased. A shellacked pattern, on the other hand, must be refinished after producing 50 or 60 castings if satisfactory results are to be obtained. (R. M. Fellows, Fellows Gear Shaper Co., Springfield, Vt., in *Machinery* (New York), vol. 34, no. 10, June, 1928, p. 739, *p*)

FUELS AND FIRING

Cheap Alcohol Fuel

SEVERAL processes have recently been proposed for making synthetic alcohol. In the French process, known as the Prodor, wood cellulose is converted into sugar (glucose) by the employment of acids, and glucose into alcohol by fermentation. The particular feature of the Prodor process is that, contrary to previous practice where hot diluted acids were used, here cold concentrated acids are used, effecting a complete conversion of the cellulose to glucose in a form which is fermentable. Instead of 7 liters of alcohol per 100 kg. of wood, the yield is about 25 liters of 100 per cent alcohol.

Hydrochloric acid is used because it can be recovered from the solution by distillation and used over and over again indefinitely. Sulphuric acid cannot be recovered. Practically any kind of wood can be used providing it is cut into pieces small enough to be readily acted upon by the acid. The process is still in the development stage. One feature of the process is that the glucose can be stored without deterioration until the alcohol is required.

The other process has been invented by Doctor Bergius, of coal-liquefaction fame, and is controlled by the International Sugar and Alcohol Co. with a plant at Vernier, near Geneva, Switzerland. No detail of this process is available but it does not seem to differ much from the Prodor process. No information as to the cost of manufacture of alcohol is as yet available. (*The Petroleum Times*, vol. 19, no. 487, May 12, 1928, pp. 868, *d*)

Powdered Coal and the Coal Industry

THE author tells in considerable detail of the history and growth of pulverized fuel. Of the practical applications it would appear that pulverized fuel is successful in the firing of kilns, such as cement, where, in fact, it made its first application on a large scale. It is also very successfully used in metallurgical plants and land central stations. In marine boilers a considerable amount of success already has been achieved, indicating the possibility of its wide application at an apparently early date. In railway locomotives a good deal of work already has been done, but to date, according to the author, the extremely high heat release per cubic foot of furnace volume—more than double that required in marine boilers and eight to ten times that for stationary boiler furnaces—leaves this problem still substantially unsolved either technically or economically. The above represents, of course, only the most outstanding applications and the author gives an interesting list of applications which proved successful and those awaiting further solutions.

In 1924 the annual consumption of powdered coal had mounted to a total of 16,000,000 tons, distributed approximately as follows:

	Tons
Manufacture of Portland cement	6,000,000
Iron and steel industry	3,000,000
Production of copper	2,500,000
Generation of power	3,500,000
Other purposes	1,000,000

Today, principally by reason of enormous strides in boiler firing, annual American totals exceed 25,000,000 tons, and world totals 35,000,000 per annum. It is estimated that there are today more than 1000 powdered-coal installations and more than 2000 boilers so fired. Besides the United States and Canada, there are now powdered-coal installations in Great Britain, Ireland, France, Belgium, Holland, Italy, Germany, Australia, Africa, China, Japan, Malay States, Argentina, Columbia, Cuba, Chile, and on the high seas.

Lest enthusiasts not familiar with the coal industry misinterpret these figures, it should be noted that the rather formidable figure of 25,000,000 tons represents but 5 per cent, or two and one-half weeks of American coal production. On the other hand, the method lends itself to more economic solutions of perhaps more than half of all coal-firing usage, so that with increasing amortization of existing equipment, wide extensions in the use of the new method may be anticipated.

The application of powdered coal to marine boilers has been tried during the war both by the United States and England. Shortly after the war tests were conducted by the U. S. Shipping Board and Bureau of Mines on Scotch marine boilers set up ashore, thus providing a more convenient testing arrangement than was possible aboard ship. This test did not lead to a successful conclusion.

For five years the subject lay dormant. During this period this writer and others became interested in extreme turbulence

in combustion as a means toward reducing the then excessive size and cost of stationary powdered-coal-fired boiler settings. This work eventually culminated in what is now commonly called the "well furnace." Similar principles variously applied have also been adapted in the so-called "steam generator" and "vortex furnace." In the "well furnace," four impinging high-speed jets of coal and air intercept one another at right angles to form a rapidly rotating circle or spiral of flame within the furnace. Perhaps the outstanding experimental installations were, first, the test plants at Fullerton, Pa., then the competitive test plant at the Sherman Creek Station in New York, where twelve competing systems, including the "well furnace" were tested, and finally the eight 1200-hp. boilers of the Buffalo General Electric Co. In England, Wood and others conducted exhaustive tests on his "steam generator" in which the flame spirals extended downward instead of upward or horizontally, as in the American experiments.

Becoming interested in these developments, Captains McAllister and Gatewood and Mr. C. J. Jefferson of the Shipping Board again instituted tests in cooperation with the Navy at League Island Navy Yard, Philadelphia. After constant modification and some two years of test, 10-day trials resulted in efficiencies of the order of 75 to 77 per cent (slightly higher than those obtainable with oil), and continuous, dependable, and substantially smokeless operation, capable of efficient usage with the labor usually obtainable at sea. With the then competitive bunker prices of coal and oil, there was a saving of nearly half the cost of liquid fuel. Operation under the practical conditions at sea were than tested by an installation on the Shipping Board converted-oil-burning freighter *Mercer*. At the time of this writing the *Mercer* is making its third round trip across the Atlantic on powdered coal.

The first voyage was a real seagoing test. Ten days of the fourteen, the vessel encountered young gales and very rough going. She rolled 32 deg. and pitched 12 deg. Mechanical difficulties developed, as might be expected on such a floating laboratory on its first voyage, but were corrected en route to the extent that in spite of difficulties the vessel not only met but *beat* its schedule by 36 hr. In the round-trip passage but 190 bbl. of oil (total) were used—about 10 per cent of that ordinarily required. This was used principally for starting the powdered-coal burners and maneuvering in port—as time to date has not permitted the solution of detail problems of extreme flexibility, nor does the operation so require, for the same burner adequately handles both coal and oil. Meanwhile tests continue at the Philadelphia Navy Yard on competitive makes of pulverizers and burners, both with the expectation of further refinement, as well as for widening the field of competition among equipment manufacturers.

Specifications for installations on six additional Shipping Board vessels are now being prepared, while experiments are also being conducted by the Government on Mississippi River type boilers on the Warrior River Barge Canal.

To give an idea of the great variety of applications of powdered-coal firing which, when properly applied and engineered can be accepted with reasonable assurance of success, the author lists upward of thirty. He also summarizes the advantages of powdered coal and gives a table of the comparative fuel consumptions of various types of furnaces.

Among other things the author discusses the effect of pulverized fuel on the coal industry which he thinks will be beneficial and gives sources of more complete information on the subject and a list of manufacturers of pulverizing and powdered-coal firing equipment. (H. W. Brooks (Mem. A.S.M.E.), Report of Research Committee, National Coal Association, May, 1928, 29 pp., illustr., *hgs*)

INTERNAL-COMBUSTION ENGINEERING (See Fuels and Firing: Cheap Alcohol Fuel)

Tests of Büchi System of Supercharging Diesel Engines

THE Büchi system (compare *The Shipbuilder*, vol. 35, no. 212, p. 238) utilizes the energy of the exhaust gases in a turbine directly connected to a centrifugal blower which delivers the supercharging air at a pressure of from 4 lb. per sq. in. up to as much as 20 lb. per sq. in. according to the rating desired. In earlier tests with a four-stroke-cycle four-cylinder engine of 500 b.hp. normal rating, an overload of 50 per cent was sustained without difficulty. The system has been applied on fast motorships *Preussen* and *Hansastadt Danzig*.

Quite recently independent tests were carried out by Prof. A. Stodola, Zurich, Switzerland. These tests were carried out on a four-stroke-cycle six-cylinder engine of the design of the Swiss Locomotive and Machine Works, standard in every way and rated without supercharger at 850 b.hp. at the normal speed of 167 r.p.m. The engine was supercharged with an exhaust-gas turbo-blower of the Büchi system.

Working in conjunction with the turbo-blower, the output was increased to 1275 b.hp. with combustion and exhaust temperatures the same as at the normal rating of 850 b.hp. Even at an output of 1652 b.hp. the engine exhaust was absolutely clear. At 1275 b.hp. the fuel consumption was 0.391 lb. per b.hp. per hr., the lower calorific value of the fuel used being 18,240 B.t.u. per lb.

The thermodynamic conditions for the cycle of the supercharged engine and the ordinary Diesel engine are the same; and if the expansion in the supercharged engine were carried to atmospheric pressure, the indicated thermal efficiencies would be the same. The mechanical efficiency of the turbo-charged cycle is much higher, however, and the fuel consumption is, in consequence, reduced in spite of the back pressure behind the exhaust valves. The maximum load on the crankshaft is the same, but the mean torsional load is higher due to the higher mean indicated pressure. As the diameter of the crankshaft, however, is proportional to the cube root of the turning moment, only a very small increase in diameter is required. This is illustrated by reference to a formula taken from Lloyds' Rules for the diameter of the crankshaft of a Diesel engine and another formula worked out by the Werkspoor Co. of Amsterdam and accepted by Lloyds. It is shown furthermore that the mechanical efficiency of the engine is increased from 7 to 8 per cent which more than compensates for the loss due to the back pressure, while the output is increased by 50 per cent.

The tests were carried out at quarter, half, three-quarter, and full load, and at 30 per cent overload. It should be observed, however, that the normal full load of 1275 b.hp. is already 50 per cent above the ordinary rating of the engine non-supercharged. The results of these tests are shown graphically in Figs. 1 and 2 while Figs. 3 and 4 of the original article (not reproduced because of lack of space) show an entropy diagram for full load with supercharging and for three-quarter load without supercharging.

The fuel consumption at normal load works out at 0.391 lb. per b.hp. per hr. The same engine running without supercharging has a consumption of 0.408 lb. per b.hp. per hr. In other words, the turbo-supercharging improves the fuel consumption for the engine tested by about 4 per cent, due to the increase in mechanical efficiency from 72 to 80.2 per cent, in each case with reference to the normal rating of the respective motor. Another feature of the system is the reduced amount of heat passing through the walls of the piston, cylinder, and cylinder head, i.e., 1620 B.t.u. per b.hp. per hr. at full load. Assuming that the whole heat carried away in the piston cooling water passes through

the piston head, the amount in B.t.u. per sq. ft. per hr. is

$$Q_1 = \frac{530 \times 1270.5}{15.89} = 42{,}500$$

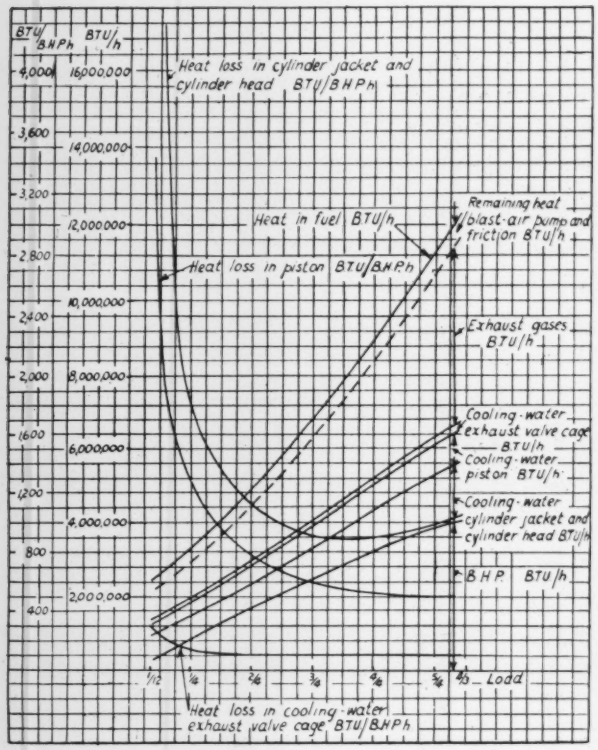

Heat loss in cylinder jacket and cylinder head BTU/B.H.P.h
Heat in fuel BTU/h
Heat loss in piston BTU/B.H.P.h
Remaining heat (blast-air pump and friction) BTU/h
Exhaust gases BTU/h
Cooling-water exhaust valve cage BTU/h
Cooling-water piston BTU/h
Cooling-water cylinder jacket and cylinder head BTU/h
B.H.P.
BTU/h
Load
Heat loss in cooling-water exhaust valve cage BTU/B.H.P.h

FIG. 1 HEAT BALANCE OF SINGLE-ACTING DIESEL ENGINE WITH BÜCHI SUPERCHARGING

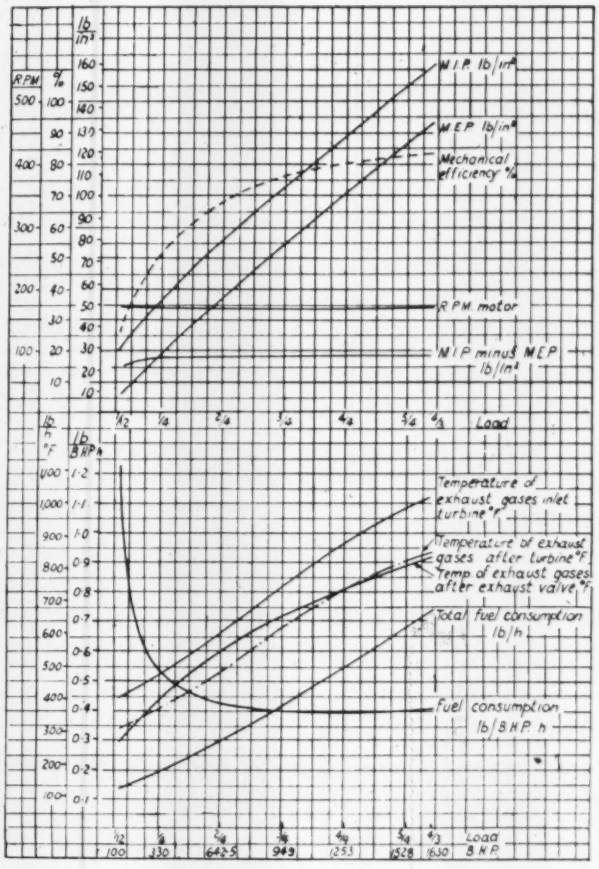


FIG. 2 RESULTS OF TESTS WITH SINGLE-ACTING DIESEL ENGINE WITH BÜCHI SUPERCHARGING

The average for the inner cylinder walls heated by the exhaust gases is only 27,300 B.t.u. per sq. ft. per hr., which is much less than for ordinary four-stroke-cycle Diesel engines. According to a paper by Hottinger, published in Zeitschrift des Vereines deutscher Ingenieure for 1911, p. 673, an engine of a similar speed, but with uncooled pistons and a fuel consumption of 0.41 lb. per b.hp. per hr., showed a loss through the cooling water of 28.7 per cent of the heat value, which is equal to 2130 B.t.u. per b.hp. per hr.

Comparative tests were made at three-quarter load with and without a turbo-blower in action and the results are given in a table in the original article. Among the conclusions are the following: Temperatures of the combustion and of the exhaust gases with supercharging are the same as or even lower than those of the ordinary Diesel engine without supercharging, and the fuel consumption per b.hp-hr. is lower and less heat is carried away in the cooling water. The absolute quantity of the latter is 42,500 B.t.u. per hr. per sq. ft. of piston area which is a very small amount for the size of the engine. (*The Shipbuilder*, vol. 35, no. 214, June, 1928, pp. 413–416, 4 figs., *e*)

MACHINE PARTS AND DESIGN

Transmission Gear Lapping and Noises

THIS article deals with the lapping of gears and among other things tells of an investigation of the causes of gear noises.

In the case at hand, two designs of transmission gears were produced by the same plant for two different automobile concerns. The load and other conditions existing in one transmission were such that little noise was noted, even with gears whose teeth might be called only rough-cut. On the other hand, the second transmission had narrow gears and high tooth pressures, with the result that they were noisy, in spite of the greatest care in cutting.

That an error of as little as 0.00025 in. might cause noise, as some of the best authorities on gears have stated, was at first contradicted, and so in order to obtain the facts in the case, a Lees-Bradner profile tester was so altered that the profile and spacing for a given gear under observation could be determined time after time, and readings obtained checking with variations seldom exceeding 0.00005 in. Some 2500 readings were made on various gears (some quiet, others noisy, and some tested after hardening, etc.), bore out the statement regarding the 0.00025-in. error and proved that the errors in profile and spacing introduced by distortion during heat treatment were equal to or greater than the difference between errors of a satisfactory gear and a rejected one. This naturally brought up the question of grinding the gears, but to the author this did not appear to be feasible, the results in production being questionable and the matter of cost putting it entirely out of bounds. An improved method of lapping was therefore proposed, and has proved satisfactory after extended use.

The article describes in detail the process of lapping, and states that not only has the general production been improved but hundreds of sets of gears that had been previously marked for scrap on account of faults in cutting, such as flats, have been salvaged. When one man can load, lap, unload, and wash gears

at the rate of one set in 5 min., it is evident that the cost is not excessive and it is certain that the method is many times cheaper than gear grinding.

Among other things, the article explains why gears wear less at the pitch line and why badly worn teeth often show a decided high ridge on the pitch line. (Merritt R. Wells in *Machinery*, vol. 34, no. 10, June, 1928, pp. 749–751, 4 figs., *ep*)

MACHINE SHOP

Diamond Boring of Connecting Rods

DIAMOND tools are becoming increasingly popular in automobile plants for boring the bearings of connecting rods, because of the high degree of accuracy easily obtainable by their use. Both bronze and babbitt bearings of the rods may be bored by this method simultaneously. The two bearings in one plant are not only produced within the close limits specified on the diameters, but with bearing surfaces in excess of 90 per cent, as determined by wringing them on a lightly blued plug. Both bearings are also parallel within 0.002 in. as gaged between plugs at a distance of 10 in. from the connecting-rod center line. The parallelism is checked not only in the plane passing through the two axes but also in planes at right angles to the first and passing through the separate axes. Center-to-center distance between the bearings is held to limits of ±0.001 in. With this method bell-mouthed and out-of-round holes are eliminated, and straightening operations after machining are unnecessary. Efforts are made by the company using this method to control all operations on the connecting rod leading up to the diamond-boring operation in such a manner as to reduce as far as possible all of the stresses that would otherwise result in distortion of the finished rod in service.

The original article describes in detail how the diamond-boring operation is performed. Among other things it is stated that there are three types of diamond-boring machines. In one type, the work-holding fixture is mounted on a movable carriage while the diamond-boring spindles and their driving motors are held in a fixed position and the work is moved to them. In the second type of machine, the work-holding fixture is held stationary, while the boring spindles and their motors are mounted on a carriage which moves to and from the work. In the third type, which is used in the plant described in this article, the work-holding fixture and the spindle-driving motors are held stationary, while the spindles themselves are located on a movable carriage and are traversed to and from the work. The tool spindles are driven by means of splined shafts, which permit end movement of the spindles while rotating.

In all types the matter of accurate spindle bearings is very important. The design of the bearing, however, is secondary to the precision with which it is fitted for diamond boring service, and the author describes in some detail how this is done. After the bearings have been properly marked to make the ends of the inner and outer races meet properly the bearing is rotated in a bath of jeweler's rouge and oil, which causes the blast to develop an area of contact on the outer races that corrects any imperfections in the races or lack of uniformity in the balls. This operation is known as the Alden developing process, and has been patented in England. Amplifying gages for checking the looseness of each bearing are also employed. (C. R. A. in *Machinery* (London), vol. 32, no. 812, May 3, 1928, pp. 129–131, 6 figs., *d*)

MARINE ENGINEERING. (See Internal-Combustion Engineering: Tests of Büchi System of Supercharging Diesel Engines)

METALLURGY

Non-Continuous vs. Continuous Sheet Rolling

WHEN the continuous mill for rolling strips to sheet width appeared it was feared that it would completely displace the old type sheet mill. A year has gone by, however, without the scrapping of any of the old type mills. The following is suggested as the reason for this situation. The continuous mill was intended from the start as a means of doing in a more rapid and economical way roughing work, the product to be finished on a non-continuous hand-operated mill.

Of late, two companies owning continuous mills have announced that a considerable part of the production of these mills will be marketed as strip-mill breakdowns rather than as finished sheets or strips. The decision indicates a realization that with two wide strip-mill installations already in operation with a monthly capacity of 30,000 tons each, another one with 25,000 tons, and one building with 30,000 tons or more in addition to a mill at Ashland and one in the St. Louis district, the capacity of which is not given, the market is not broad enough to absorb profitably the product of these mills fully finished. Marketing of strip-mill breakdowns means the narrowing of the demand for sheet bars but probably the reduction in the cost of making finished sheets and black plate will follow so that eventually costs for strips and sheets will be much nearer parity. (Editorial in *The Iron Age*, vol. 121, no. 26, June 28, 1928, p. 1836, *g*)

Open-Hearth Furnaces With Auxiliary Hearths

THE PURPOSE of the auxiliary hearth is to increase the output of the furnace by melting the solid pig iron of the charge when cold pig iron is used. In furnaces which use a large percentage of scrap, say, 60 per cent, the pig iron is melted in the auxiliary hearth, and when required it is stopped and poured into the heated scrap charge in the main hearth. In those mills where hot metal is available it is poured into the auxiliary hearth partially refined, the temperature increased, and the metal is then packed and poured into the main hearth to be worked out into finished steel. In order to augment the heat available from the main hearth in the auxiliary hearth, gas jets are used for melting or refining the pig iron.

It is stated that a furnace of this type has been operating for several months with satisfactory results. Without increasing the area of the center or main hearth, the output has already been increased by at least 50 per cent in six furnaces which are working the same mixture of cold pig iron and scrap as they were before. The furnace which is being supplied with hot metal has increased its output by more than 33 per cent, and a greater increase is expected as soon as a larger area in the auxiliary hearth becomes available. (Presidential address by Benj. Talbot before the Iron and Steel Institute meeting in London, May, 1928; abstracted through *Foundry Trade Journal*, vol. 38, no. 612, May 10, 1928, pp. 334–336, 2 figs., *d*)

POWER-PLANT ENGINEERING (See Engineering Materials: Properties of Materials for Use at High Temperatures With Special Reference to Boilers for Superheated Steam)

"Live-Banking" Boilers

THE present article deals with the live banking of boilers at the Riverside Station of the Northern States Power Co. at Minneapolis, Minn. It is used, however, also in some of the other plants of the same system. After the construction of the High Bridge Station the Riverside Station which formerly

carried base load came to be used for peak load and stand-by duty only. The problem therefore arose of maintaining the fires in the best condition for immediate use in case of disturbance of water-power lines with which the station is interconnected as a steam reserve. This necessitated obtaining the maximum boiler-room efficiency under low-load conditions. The method of live banking has been selected.

In live banking the boilers are operated with a stoker covered with burning fuel down to the dump grates. The stoker runs for various short periods in every hour, from 5 to 15 min., and Table 3 shows the results obtained under these various conditions.

TABLE 3 "LIVE BANKING" BOILERS AT RIVERSIDE STATION, MINNEAPOLIS

Stoker operation, min. per hr.	Pounds coal fired	Approximate boiler rating, per cent	Temperatures, deg. fahr. Steam	Flue gas leaving superheater	Flue gas leaving boiler	Steam pressure, lb. gage	CO_2, per cent
15	1400	35	440	448	397	215	10.3
10	945	24	440	453	400	215	7.1
5	570	14	433	431	389	215	4.6

The 15 min. operation of the stoker was found to maintain the fuel bed in excellent shape for a sudden increase in rating. (Lawrence Washington, formerly Assistant Results Engineer, Riverside Station, Northern States Power Co., Minneapolis, Minn. in *Combustion*, vol. 18, no. 6, June, 1928, pp. 371–372, 1 fig., *p*)

The Present Trend in Boiler Practice

THE author asks himself whether it is better to have a boiler bought separately and then reinforced with various water walls according to test or to have a heating surface designed as a coherent wall by the boiler maker.

The division of the duty according to the latest ideas is to arrange a large portion of the heating surface so that it may "see the fire." This decreases the work done by the back of the boiler. To what extent may the "boiler" be thus called, and when does it become an "economizer?" The Heat Engine Trials Committee in its Report (1927) states of an economizer: "It should have no steam space, since it is not designed to generate steam." This was true; but latest developments introduce a steaming economizer, well thought out and connected to the boiler proper so that it should and may steam with impunity.

Designs for the higher steam pressures have so far developed that boilers with a working pressure of 800 lb. per sq. in. are now being made without any rivets. The drums are hollow forged, and all joints are made by expanding. On the Continent welded drums are allowed, but in Great Britain they have not yet been accepted, though how soon they may be is an open question. A short time ago the Board of Trade passed no boilers working at a pressure exceeding 250 lb. per sq. in. but now there are boilers with a pressure of 500 lb. per sq. in. on ships under their survey. (Wm. H. Patchell, *Engineering Conference*, 1928, *The Institution of Civil Engineers*, Group 2, paper no. 19, pp. 17–20, *g*)

Recent Improvements in Turbine Generators

PRACTICALLY all of the improvements with which the authors deal have to do with the problem of building bigger and bigger generators. In the two-pole 1500-r.p.m. class the maximum output of a single generator in 1925 was 66,700 kva.; at the present time there is under construction a single unit of 160,000 kva. In the four-pole 1800-r.p.m. class the maximum rating in 1924 was 44,400 kva.; at the present time a unit of 94,000 kva. is being built.

One of the difficulties in the construction of these very large generators had to do with cooling. Five years ago it became increasingly difficult to supply all the cooling air from both ends of the machine not only because of the excessive air pressures required but because of the increase in temperature of the cooling air as it passed through the machine. This latter factor was particularly important in long, axially ventilated machines.

Multiple radial ventilation solved this problem, and it is now possible to obtain fully as uniform a temperature distribution for core lengths of 250 in. as for 100 in. Generators cooled with hydrogen are also under construction and while no machines have exactly been installed with hydrogen as a cooling medium several generators have been sold with the provision that hydrogen may be used later and a large synchronous condenser has been sold for immediate installation with hydrogen cooling. The Westinghouse Company has an experimental 7500-kva. generator operating with hydrogen cooling. The most important advantage connected with the use of hydrogen is the reduction of windage loss.

The subject of working stresses in big generators is complicated by the fact that at certain points bending stresses act in conjunction with the centrifugal stress. At those points the application of stress is two- and sometimes three-dimensional, and the variable components of the stress must be considered with proper allowance for stress concentration.

One of the most important advances during the last years is

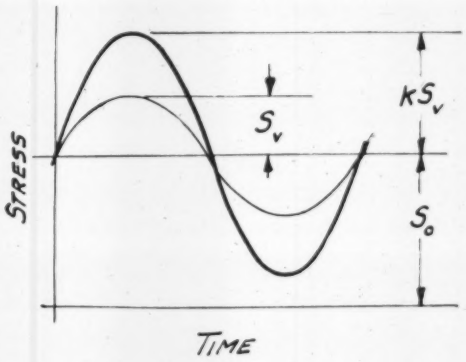


FIG. 3 GENERAL STRESS CYCLE

(S_0 = Static component of stress; $k\,S_v$ = variable component of stress; k = factor of stress concentration.)

a better appreciation on the part of the designers of the fact that the stress problem has two aspects. One is the comparatively simple one of determining the stresses that actually exist in the structure. The other is the far more difficult one of determining the actual condition of failure under these stresses. The solution of the latter problems finds its expression in the determining of true factors of safety, and in the actual values of the allowable working stresses. In view of the importance of this problem it may be of interest to review briefly the present attitude of Westinghouse engineers.

In cases of *steady stress* in ductile materials, the *yield point* is regarded as the fundamental basis for the selection of the working stress. The failure of the material is attributed to shear, so that in cases of three-dimensional applications of stress, the *maximum-shear theory*, giving the maximum difference of the principal stresses as the critical stress, is made a basis for determining conditions of failure. Conditions of stress concentration are generally disregarded for steady stresses in ductile materials. The factor of safety is thus the ratio of the yield point to the average critical stress.

Cases of *variable stresses* in ductile materials offer a somewhat greater difficulty, but even here it has been possible to obtain a logical definition of the true factor of safety. One of the most

important features of applications of variable stresses is that the conditions of stress concentration must be taken into account, so that the stresses obtained by ordinary elementary formulas must be multiplied by a factor of stress concentration k. This, however, applies to the variable component of the stress only. In the case of complete reversals of stress in one direction the *endurance limit* for complete reversals is regarded as the fundamental basis for the selection of the working stress. The factor of safety is thus the ratio of endurance limit to maximum alternating stress.

In the more general case of a variable stress, which is superimposed upon a steady stress, it has been found that the available experimental data are interpreted in a logical manner if the actual factor of safety n is determined by the formula

$$\frac{1}{n} = \frac{1}{n_o} + \frac{1}{n_v}$$

where n_o and n_v are the factors of safety of the static and variable components of stress, respectively, when acting alone.

$$k S_v = \frac{\frac{S_y}{n}}{\frac{S_u}{n}} \left[\frac{S_u}{n} - S_o \right]$$

whence

$$\frac{1}{n} = \frac{S_o}{S_y} + \frac{kS_v}{S_e} = \frac{1}{n_o} + \frac{1}{n_v}$$

Cases of two- or three-dimensional applications of stress are treated by the maximum-shear theory. It is necessary only to determine the most dangerous plane and the steady and variable component of shearing stress in this plane. The result is a cycle of shearing stresses similar to Fig. 3. Upon this cycle the postulated definition of factor of safety can be applied.

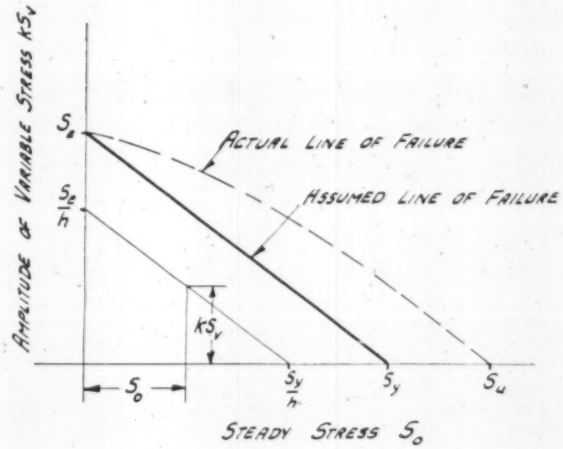


FIG. 4 CONDITIONS OF FAILURE UNDER GENERAL STRESS CYCLE IN ONE DIMENSION

The authors discuss also certain electrical features, and among the mechanical features the so-called plate rotor and forged rotor, as well as the critical speeds. In the latter connection the authors mention the attitude of many users and some designers who feel that it is very desirable to have the calculated value of the critical speed above the operating speed.

This attitude has actually been the cause of numerous cases of vibration troubles, not to mention the important fact that it has constituted a damper on the logical expansion of the individual size of the units. The reason for these troubles has been found to reside in the fact that the actual critical speed of the rotor is determined, not only by its own flexibility, but also and often to a greater extent, upon the flexibility of its supports. This influence is so great for large units with rigid rotor structures, that the recorded values of the critical speeds are frequently only half of the calculated values. As a result of this, many machines have been forced to operate very near to the actual critical speed.

The flexibility of the bearing supports is only one of the factors which cause the great discrepancy between calculated and recorded values. A fully satisfactory perspective of the problem is obtained only when the entire unit, with its foundation, is treated as one problem. It is here that the real limitations of mathematical analysis comes to light, and the practical designer is made to feel the true importance of intuitive judgment and good luck. In the opinion of the authors the term *critical speed* has assumed a significance entirely different from that of a calculated value for the rotor alone. (S. L. Henderson and C. Richard Soderberg, both of Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., in *Journal of The American Institute of Electrical Engineers*, vol. 47, no. 6, June, 1928, pp. 411–415, 6 figs., *dt*)

The Heat Pump in the Operation of Evaporators: Vapor Compression and Steam-Pressure Transformation

THE term heat pump is applied to a device, the purpose of which is to increase the temperature of gases and vapors by raising their pressure. In steam engineering the usual method of increasing the heat content is by evaporation in a boiler, while in the case of a heat pump, mechanical compression is used to increase the heat content. The practical purpose of the device may be of various kinds. It is mostly used in evaporation, but recently it has been also used to increase the heat content in steam systems.

HEAT PUMP FOR EVAPORATORS

This is shown diagrammatically in Fig. 5. The vapor generated in an evaporator of some kind is delivered to a compressor where its pressure is increased. When this latter is done a rise of temperature is created so that the vapors can now be used for heating the evaporator. The compressor may be of any practical type such as turbo, reciprocating, or jet. Since, however, very large volumes of vapors have to be handled, turbo and jet compressors are preferably used. The idea of multiple handling of the vapors generated in an evaporator is not new. The question is merely under what conditions it is desirable to apply the heat pump to an evaporator. Fig. 6 shows evaporation with heat pump as compared with evaporation with multiple-effect evaporators.

The curves are based on the use of a steam-driven turbo-compressor and show the very favorable effect of the heat pump on the steam consumption which, however, is due not exclusively to the use of heat pump but in part also to employment of live steam. This is important because many concerns operate evaporators successfully by exhaust steam which would change the economic value of the curves in Fig. 6 and in many cases might make multiple-effect evaporation preferable.

From a practical point of view evaporation with a heat pump may be considered as limited to the following cases:

1 The heat pump applies where for technical reasons evaporation should be carried out only within a definite, quite narrow, range of temperatures, which from the start precludes the use of multiple-effect evaporation. As an example may be cited the evaporation of numerous organic liquids.

2 The heat pump also applies where the power consumption of a plant is at no time lower than the heat steam consumption.

Live steam may then be used in whole or in part for operating a single-effect evaporation unit.

3*a* The power consumption of a plant is only from time to time in line with the steam consumption. In such cases live steam has to be used most of the time for operating the evaporator plant.

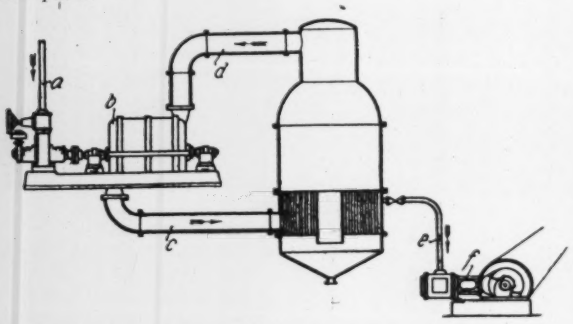


FIG. 5 DIAGRAMMATIC VIEW OF AN EVAPORATOR PLANT WITH HEAT PUMP

(*a*, live steam; *b*, turbo-blower direct connected to steam turbine; *c*, compressed vapor; *d*, vapor in suction; *e*, deaerator; *f*, dry-air pump.)

3*b* As in 3*a* the power consumption is only for certain periods in line with the steam demand. In that case operation with approximately constant power generation is possible only on the assumption that during the period of reduced demand for current the excess of power is supplied to an electrically operated vapor compression plant.

4 The heat pump is also applicable where particularly favorable conditions of current generation prevail, such as the possibility of using night current (i.e., off-peak load) from municipal or state central stations. In such a case the current supply to the plant is so favorable that an electrically operated single-stage evaporator with vapor compression is economically superior to multiple-effect evaporation.

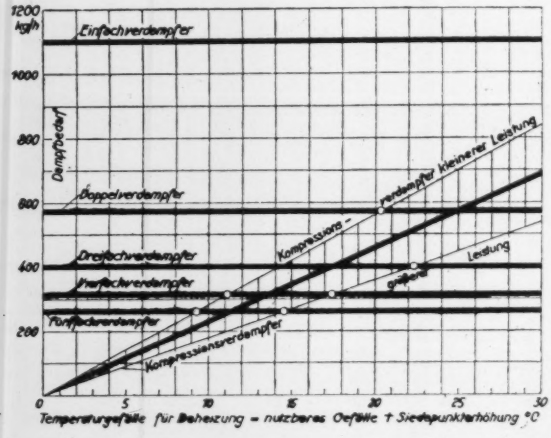


FIG. 6 CURVES OF STEAM CONSUMPTION FOR A VAPOR COMPRESSION PLANT WORKING WITH LIVE STEAM AT AN OUTPUT OF 1000 KG. OR 2200 LB. PER HR.

(*Einfachverdampfer* = single stage evaporator; *Dampfbedarf* = steam demand; *Doppelverdamfer* = double-effect evaporator; *Dreifachverdampfer* = triple-effect evaporator; *Vierfachverdampfer* = four-effect evaporator; *Fünffachverdampfer* = five-effect evaporator; *Kompressions-verdampfer kleinerer Leistung* = compression evaporator of comparatively small output; *Kompressionsverdampfer grösserer Leistung* = compression evaporator of comparatively large output; *kg/h.* = kilograms per hour; *Temperaturgefälle für beheizung* = *nutzbares Gefälle* + *Siedepunkterhöhung* °C. = Temperature head for heating = useful head + rise of boiling point in deg. cent.)

In case No. 1, i.e., where the character of the liquid is such that evaporation must take place within a narrow temperature range, obviously only a single- or at most a two-stage evaporator can be used. In such a case steam can be saved only by the use of a heat pump. As the turbo-compressor is not well suited to rough mechanical usage the development of a steam-jet compressor, working at high efficiency, would be a very good solution of the problem in this case, particularly for the smaller plants. According to Fig. 7 the energy of the live steam or exhaust steam used for heating a single-stage evaporator is utilized to compress the vapor thus generated and deliver it back to the heating element. The liquid used may be of such a character that when compressed it shows a material rise in the boiling point, or else because of the increase of viscosity, the temperature range that has to be employed toward the end of evaporation may be too great. In such a case a sub-division of single-stage evaporation may be employed. The first part in which the major volume of the water is evaporated takes place under conditions of vapor compression with a lower temperature head. The rest of the dehydration is carried out either by means of the exhaust steam or else by employing a second vapor compressor operating with a higher temperature range.

The original article shows a photograph of a plant used in a tomato canning factory handling 120,000 kg. (264,000 lb.) of raw tomatoes a day. The evaporator equipped with vapor compression handles 4000 kg. (8800 lb.) of steam per hour and consumes 1700 kg. (3740 lb.) of steam per hr. in doing it. The plant is located in Italy in a section where water is scarce. Here therefore another advantage of the use of a heat pump comes into being, i.e., its comparatively low cooling-water consumption. As only the excess vapor capacity has to be condensed, the cooling water consumption is one-half or less of that of plants not equipped with vapor compression.

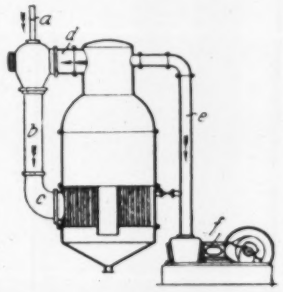


FIG. 7 DIAGRAMMATIC VIEW OF EVAPORATOR PLANT WITH JET COMPRESSOR

(*a*, live steam; *b*, steam-jet blower; *c*, compressed vapor; *d*, vapor in suction; *e*, excess vapor and deaeration; *f*, wet-air pump.)

The next possible field of employment of the heat pump is in plants where it may be helpful in maintaining the proper relation between power generation and evaporation. This applies particularly to plants where complete coordination between demand for power consumption and process steam is not feasible.

The first case that may be considered in this connection is that of an evaporator plant which, because of the lack of sufficient exhaust steam, has to be operated with decompressed live steam. Such a method of operation entails obviously a constant waste of energy. One way to avoid the throttling losses consists in installing an evaporator plant equipped with either a turbo-compressor or a steam-jet compressor. As has been mentioned above, preference for practical reasons is usually given to a simple jet compressor. Should a jet compressor be selected, throttling losses can be avoided only by doing as shown in Fig. 8, i.e., installing a jet compressor ahead of an evaporator plant using live steam. A part of the potential energy of the steam is then converted into kinetic energy in the jet compressor.

The energy is then used to compress a given amount of vapor taken from the cooker of an evaporator set back of the compressor and in the case of a multiple-effect evaporator plant taken from the first element. In a process assumed to be free from losses, it is possible to increase the coefficient of evaporation of a three-effect evaporator from 3 to 4 and of a two-effect evaporator from 2 to 3, assuming that the carrying ratio of the steam-jet compressor is approximately one (which corresponds to actual

practice). Actually, however, the results cannot be made quite as good as that because there are certain losses. Assuming however that 1.1 kg. of steam evaporates 1 kg. of water in a single stage of an evaporator then the carrying ratio is obtained for a double-effect evaporator with a vapor compressor ahead of it as follows: $W = 1.74\ F \times (1 + 0.48\ f)$ and for a triple-effect evaporator $W = 2.49\ F \times (1 + 0.30\ f)$ where W is the evaporation of water in kilograms per hour, F the amount of live steam employed in kilograms per hour, and f the carrying ratio of the evaporator or ratio of the steam taken in by suction to the carrying steam. According to the above formulas, under practical conditions the double-effect evaporator will have a coefficient of evaporation of approximately 2.55, and the triple-effect evaporator 3.25, and these coefficients may be higher where the steam conditions are favorable. The original article shows an illustration of a plant of that kind where the total evaporation of water is 4200 kg. per hr. (triple-effect unit with vapor compression) while the live steam consumption is 1300 kg. per hr. These figures are materially superior to those for the normal multiple-effect evaporation unit.

In the third of the cases listed above, namely, the one where

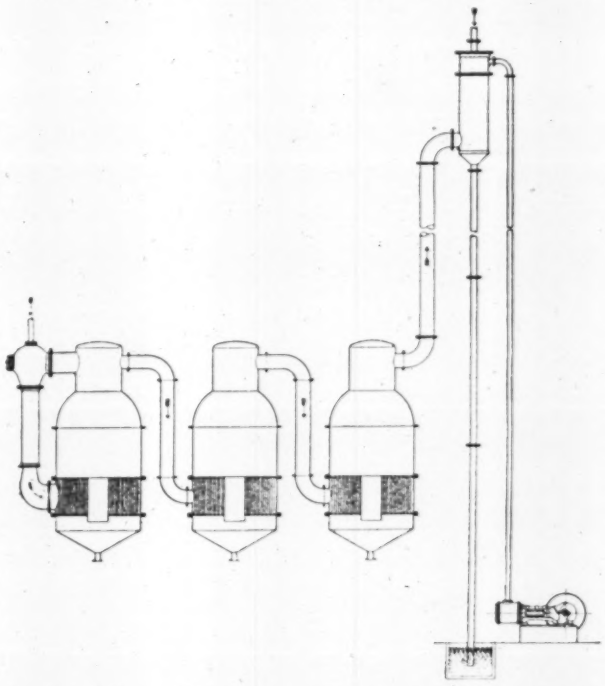


FIG. 8 DIAGRAMMATIC VIEW OF A MULTIPLE-EFFECT EVAPORATOR PLANT WITH VAPOR COMPRESSION HEAD OF THE EVAPORATORS

there is at times a material difference between the output of power and demand for process steam, jet compression may be used to cure the lack of steam, live steam being added to that coming from the pump. Fundamentally, the arrangement here would be the same as in the previous case.

For the last case, namely, one where during part of the time the power and heating steam demand do not properly fall in line together, there is another way out of the difficulty which is that the power plant does not run at full load the whole time, but at times of less load produces current in a volume in excess of that required by the plant. This excess current is then used to drive electrically operated turbo-compressors connected to the single-effect evaporator plant. This may happen when, for example, because of improved methods of steam consumption, the energy generated from a given amount of steam has become larger than it was previously or else when the exhaust steam corresponding to a given normal generation of power is not sufficient for single-effect evaporation operation. In such a case a given amount of the excess of energy generated can be employed for evaporation by way of turbo compression. The original article shows a photograph of such an installation in a sugar factory where by an installation of an electrically driven turbo-compressor of 1100 effective hp. a saving was made of 12,500 kg. (27,500 lb.) of steam per hr. in the operation of single-effect evaporators. Where vapor compression is employed the matter of design of evaporator becomes of very great importance.

The illustration in the original article shows one such single-stage evaporator with steam-jet compression of a single closed construction. Because of the fact that in evaporators it is particularly important to utilize uniformly the entire heating surface, the design of the evaporator should be such as provides for ease in removing scale. Because of this, in installations where a heat pump is used, not only has the heating surface been divided into sections but self-cleaning evaporators have been employed. One such installation is shown but the illustration in the original article is not good enough to permit reproduction here.

TURBO AND JET COMPRESSORS

Substantially only these two types can be considered for purposes of vapor compression and the author discusses their relative merits. The conclusion to which he comes, however, is that local conditions will govern the selection.

The next subject discussed is the use of the heat pump as a steam converter. This term has been applied to two types of apparatus. In one the superheated steam was converted into saturated steam without reduction in pressure, and in the other, superheated steam was obtained from low-pressure steam by compression. The author uses the term "steam conversion" only as applied to the second of these cases. This part of the article may be abstracted at some later date if space should be available. (Dr. of Engrg. A. Oetken, Frankfort a. M., in *Die Warme*, vol. 51, no. 17, Apr. 28, 1928, pp. 315–321, 16 figs., *dA*)

POWER TRANSMISSION

Variable-Speed Transmission in Paper Mills

THE author describes a number of installations and divides the transmissions into three types—mechanical, hydraulic, and planetary. He gives a detailed calculation of cost of installation and operation of the various transmissions and savings made by their installation, but comparatively few details of a technical character. Only a small part of this article can be abstracted.

In connection with the application of variable-speed transmissions to roofing and corrugating machines, it is noted that for several years efforts were made to run them at constant speed but with very little satisfaction. Such drives did not provide the necessary flexibility, and it was found that the employment of variable-speed transmissions was essential.

The use of variable-speed transmissions for driving cylinder and Fourdrinier paper machines makes it possible and quite feasible to run any weight of paper desired, from the finest tissue to the heaviest wrapping paper, without having to stop the machine or break down the paper end. That is, with such systems of speed regulation and control, any degree of paper or machine speed, from the minimum to the maximum of the device's speed range, may be secured almost instantly, without stopping the machine or interrupting production.

In fact, so very sensitive is the regulation and control of speed by the modern approved forms of variable-speed transmissions, that such devices are now quite frequently incorporated or

attached as standard equipment for changing the ratio between the speed of an engine or turbine shaft and that of the functioning speed governor. Where only a few grades and weights of paper are produced, this speed control at the prime mover has quite frequently been found to suffice, but wherever a greater variety of output is called for from a machine, the more sensitive regulation secured by having the machine driven in whole or in sections through variable-speed transmissions is to be preferred. Furthermore, in the approved types of variable-speed transmissions, remote control of machine and section speeds have been developed, the control being effected through push-button stations located along the paper machine or at other strategic points.

(Part of a serial article under the general title, "Modernizing the Mill and Power Plant," in *Paper Trade Journal*, vol. 86, no. 20, May 17, 1928, pp. 44–50, 13 figs., *d*)

RAILROAD ENGINEERING

An American Locomotive With Caprotti Poppet Valves

THE Baltimore and Ohio Railroad Company, in March, 1927, installed a set of these valves on its Consolidation engine No. 2722 and certain tests were made, the data of which are not yet available for publication. It is stated, however, that these tests proved the economy and practicability of the valve gear, and established very low figures of water and coal rates per indicated horsepower.

Including the test runs, engine 2722 has operated for about 20,000 miles and has taken its regular turn in the freight service of the Baltimore & Ohio Railroad on the Wheeling Division. The engine is well liked by crews and roundhouse workmen, as it has many features of simplicity not ordinarily met with on American railways.

The following points out the principal details of its construction. In place of the usual piston valve of 200 lb. weight, engine 2722 employs four separate poppet valves on each side, the combined weight of which is 14¼ lb. These valves are double-seated and are forged from chrome-nickel steel, heat treated. They are approximately 6¼ in. in diameter and have no rings or packing. The seats are merely ground in, in the manner of grinding valves for automobile engines.

The actuating mechanism consists of a gear box clamped to each cylinder and a longitudinal-motion shaft geared to the driving axle.

There are no links, eccentrics, eccentric rods, arms, combining levers, radius rods, or any of the mechanisms familiar to the ordinary locomotive.

The feature of interchangeability of gears between engines of different classes is well exemplified by engine 2722, which has a set of gear boxes and valves taken from stock manufactured originally for the two-cylinder Consolidations on the Italian State Railways. The Caprotti gear is so designed that the same gear boxes can be applied to varying classes of engines with differing wheel arrangements and with cylinders varying from 16 to 30 in. in diameter. This is a feature unusual to locomotive practice in the United States, and is one worthy of close consideration when economy is desired.

The gear boxes are also interchangeable right and left, and in case of a breakdown a spare box can be applied to the engine in a few minutes.

The setting of valves is a simple operation, requiring no rollers, trams, or special apparatus, and usually occupying less than one hour, including ordinary adjustments.

Either gear box can be removed from the engine by removing two clamps, and each individual valve can be removed while the engine is hot in a very short time by the ordinary roundhouse crew. Grinding of valves is necessary only at long intervals.

Caprotti valves work vertically in the cylinders and require no stem packing and no lubrication. The actuating cams in the gear box run in a bath of oil which is renewed at intervals of six months to a year, with small amounts of fresh oil occasionally supplied to account for leakage. The cam mechanism is not in the path of the steam, but is entirely external to it; therefore the lubrication is not subject to breakdown by heat or emulsification.

Reversing and cut-off control are effected by means of a light lever which merely shifts the cams in the gear box and has no thrust from the valves.

The largest engines require no power reverse, and the cab lever is entirely free from all "kicking." It can be unlatched and held by hand in any position and at any speed of the engine or at any amount of throttle opening. This feature also allows control of "slipping" in the logical manner by using the reverse lever without closing the throttle.

In the Caprotti system the exhaust valves are independent of the inlet valves, and there is no change due to cut-off. The Baldwin Locomotive Works are the licensees for Caprotti gear in the United States. (*Baldwin Locomotives*, vol. 6, no. 3, Jan., 1928, pp. 67–68, 2 illustr., *d*)

REFRIGERATION

Ethyl Chloride Rotary Compressors

DESCRIPTION of a high-speed conchoidal or "crescent" type compressor successfully built by the Société Nouvelle du Froid Industriel.

The type in itself, as a conception, does not pretend to be novel, but a superiority is claimed from the standpoint of mechanical

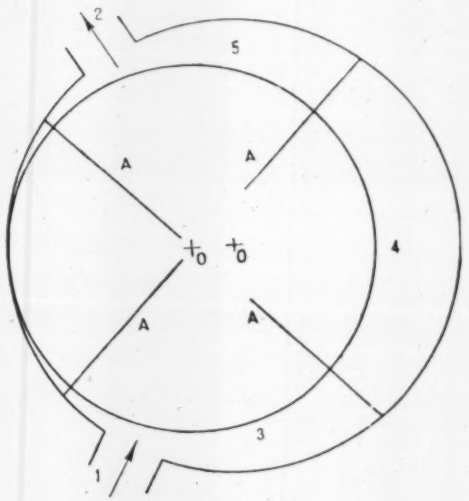


FIG. 9 DIAGRAM SHOWING PRINCIPLE OF "CRESCENT" TYPE ROTARY COMPRESSOR

(*A*, Mobile blades lodged in the rotary part of the machine; 1, Communication of the compressor with the suction; 2, Discharge exit; 3, Suction phase; 4, Compression phase; 5, Discharge phase; *oo*, Eccentricity.)

efficiency. The principle is indicated in Fig. 9. It is composed essentially of a hollow cylinder in which a solid one rotates on an eccentric axis, the two curved surfaces being tangential to each other. Paddles, or blades, lodged in grooves and projected by centrifugal force or through the action of springs, isolate the suction and discharge orifices, thus insuring, during the revolution of the pistons (as is the classic apparatus), the three periods of normal compression, namely, admission, compression, and discharge to the condenser.

The external hollow or fixed cylinder is thus connected with the evaporator, on one hand, and the condenser on the other.

The normal vacuum of the "crescent" type quite easily attains 3 to 4 mm. abs., thus leaving far behind it the achievement of any piston machine.

When the rotor of the conchoidal type continues its post-aspiration movement the fluid is compressed and driven off to the condenser shortly before the blade piston returns into contact with the external hollow cylinder. As there are no suction or discharge valves there is an almost total suppression of the detrimental-space effect and an increase of volumetric efficiency.

The axis and the eccentric revolve on ball bearings; the friction between the outer cylinder wall and blade faces is reduced by pressure lubrication, the oil being integrally separated at its exit.

Experience has shown the necessity of having the eccentricity at a minimum, 5 per cent for small and 10 per cent for medium compressors. The advantage of this is thus explained: The space in the form of a crescent, where the high pressure is produced and a powerful suction exercised, is then extremely narrow in the neighborhood of the point of contact. The layer of oil that the piston carries along with it helps to heighten the tightness. To obtain a perfect result the manufacture of the rotary pistons must be effected with the greatest care and precision; the pistons must be very solidly wedged on the shaft because of unequal heating effects of the gas during the working.

Ethyl chloride is used because it produces only a small pressure difference between suction and discharge and also suits this particular type of compressor, owing to the volumetric displacements peculiar to it.

One such unit is used in the Bourget Aerodrome Laboratory of Medical Studies, chiefly, in connection with the study of respiration. (*Ice and Cold Storage*, vol. 31, no. 362, May, 1928, pp. 123–124, 3 figs., *d*)

SPECIAL MACHINERY

New Types of Colloid Mills

THE original Plauson mill is said to suffer from the disadvantage that it consumes a very large amount of power for the work that it does. The article here abstracted describes two designs of colloidal mills—one, a German, and another, an

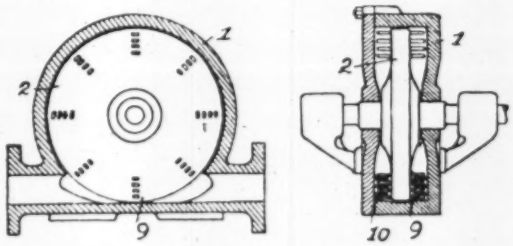


FIG. 10 CONSTRUCTIONAL DIAGRAM OF ODERBERG MILL
(1, housing; 2, rotor; 9, beaters; 10, baffles or anvils.)

American. The former, made by the Oderberg Chemical Works Co., at Neu Oderberg, Czechoslovakia, is based on the original Plauson design. In Fig. 10 the material to be milled is conducted tangentially past the beaters. The mill chamber with the exception of the beating point is empty and hence there is no rotation of the material within the housing. Fig. 11 shows the course of the material to be processed. This is premixed in the tank 6, which should be equipped with a stirrer. Depending on the size of this mixing tank (in a mill already set up the capacity was raised to 12,000 liters), an almost continuous mode of operation can be attained. Where a perfectly continuous process is necessary, the connection of several mills in series is recommended. The premixed material is conducted into the mill 1, through the pump 5, passing from there at very low velocity between the rapidly rotating beating apparatus and the baffles or anvils (9, 10, Fig. 10); it then returns to the mixing tank through the connection 4. The design of this connection has been proved to be of primary importance in relation to the power consumption. If the connection is perfectly horizontal the power consumption rises, because the friction from the interior of the housing is transferred to the upper wall of the connection; but if the connection is so designed that it encloses the path in which the material would escape into the open if no pipe were present, the power consumption drops appreciably. Careful parallel experiments have (it is claimed) demonstrated that the colloid mill on the Oderberg system, with equal performance, requires only about one-seventh of the power necessary in the case of the Plauson mill; i.e., in a colloid mill in which the material to be beaten is carried along the sides of the housing, six-sevenths of the applied power is spent in internal friction.

The new mill has still another advantage. In a Plauson mill, in spite of the eccentric arrangement of the shaft, the material being processed goes through a rotary motion which is the more rapid the higher the rate of revolution of the rotor. Hence, only the difference between the beater velocity and the velocity of the material is effective or the actual work of beating. In the Oderberg system the material passes through the mill so slowly that the full rotation velocity of the beater arms can be made available.

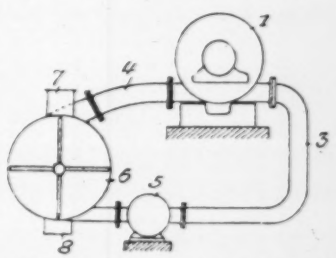


FIG. 11 DIAGRAM OF COMPLETE INSTALLATION

Because of its low power consumption the new mill can be used where the original Plauson could not. Also, it is said that solids can be disintegrated to a much higher degree than could be accomplished hitherto. Materials very finely ground acquire at times properties completely lacking in the ordinary material. Thus kaolin colloidally ground acquires high adsorptive power, making it possible to use it in place of lycopodium for dusting purposes in the rubber industries.

There are numerous cases where a material can be dispersed almost to the degree of true colloidal solution through use of the colloid mill. By varying the duration of rotation it is possible extensively to influence the degree of dispersion. In this connection it was observed that with many materials a minimum velocity of rotation, designated as "critical speed of rotation," is advantageous for attaining a certain beating effect. In the experimental investigation of the most favorable conditions of beating for a large number of materials it was found out at Oderberg that occasionally a speed of rotation of 6000 r.p.m. for one hour is more effective, and involves a lower total power consumption, than many hours' beating at 3000 r.p.m. To reach speeds unattainable by direct coupling to electric motors the use of toothed-belt gearing has proved advantageous; likewise, where the exhaust steam can be utilized, direct coupling of the mills to small high-speed steam turbines can be employed. In general, the upper limit of speed is approximately 9000 r.p.m.; a velocity of 12,000 r.p.m., tested experimentally, proved in most cases no longer economical.

Where the highest degree of dispersion is desired, it is generally expedient to combine the mechanical action of the colloid mill with chemical influence on the beating process. Peptizers and protective colloids, which are chosen according to the nature of the material, favor the milling process, without, however, com-

pletely eliminating the need of a definite minimum speed of rotation.

The other mill is built by the U. S. Colloid Mill Corporation, Long Island City, and is of interest because it consists of two adjacent rotors mounted within a casing and driven in opposite directions. This is said to result in a reduction in shaft stresses and an increase in the productive capacity of the mill. (*The Chemical Age*, vol. 18, no. 463, May 12, 1928, pp. 430–431, 7 figs., *d*)

STEAM ENGINEERING

Electric Boilers and Steam Accumulators

THE author attempts to prove that where very cheap current is available, steam generation for process purposes by use of electric boilers is an economic proposition.

The author refers to two systems of electric boilers. In the Swedish type the water level in the boiler is kept uniform and variations according to input of electricity and output of steam are obtained by raising or lowering vertical tubes surrounding the electrodes, which shorten or lengthen the path of the current. The entry of the conductor in this case is through the bottom of the boiler to vertical electrodes fixed in the base of the shell. In the German system the leads are brought in through the top, and hanging electrodes are used with piled disks of insulating material surrounding them to direct the course of the current; the work done is varied by raising or lowering the water level.

An efficiency of conversion of nearly 100 per cent is claimed for the boilers, as almost every kilowatt-hour expended is returned in heat units, the only loss being due to heat lost by radiation, and this can be materially reduced by thorough lagging of the whole of the boiler. As a matter of fact, makers of electrical boilers are prepared to guarantee an efficiency of conversion of 96 per cent. There is, however, a further loss to be considered, namely, that due to blowing off the mud thrown down from the impurities in the water. Perfectly pure water cannot be used in view of high resistance, and a certain amount of impurities is necessary. Since these impurities do not pass off with the steam the conductivity of the water gradually increases, and to maintain the conductivity uniform it is necessary to blow out the surplus and keep the water in the boiler at approximately uniform analysis. In practice this may be arrived at in two different ways, namely, a good blowdown at prolonged intervals, or so arranging the sludge cocks that a small dribble containing the surplus impurities is always running. This entails a certain loss of efficiency; with this feedwater at 68 deg. fahr., 1 kw-hr. will produce 2.75 lb. of steam at a gage pressure of 114 lb. per sq. in.

The author in his discussion refers particularly to a South American firm (at Rio) where very cheap current was available for about ten hours out of the twenty-four. The plant comprises the following:

One boiler for three-phase, 6000 volts, the maximum input being 1000 kw. and maximum output per hr. 2750 lb. of dry saturated steam at 114 lb. pressure, the dimensions being, height 7 ft. 2 in., diameter 4 ft. 6 in. All regulating and control gear, including switch cubicle, etc., were included.

One Ruths steam accumulator complete, having a capacity of 19,800 lb. of steam, its length being 57 ft. 6 in., and its diameter 10 ft., with all valves and other fitments, including oil-driven automatic valves for 80 lb. and 24 lb., respectively.

One oil-cooled transformer, 1000 kva. capacity at 6000 volts, ratio one to one, wound for delta-star.

The reason for this transformer was that the power company in Rio supplies on the non-earthed or delta system, and the supply to the boiler must of necessity be earthed; indeed, the action in the boiler is somewhat complicated, being of a combined star and delta nature, but in any case the boiler shell must be earthed, and the 1:1 transformer was the easiest and safest way out of the difficulty.

The reason for using the steam accumulator was that current was available only for part of the time, and the accumulator took care of the period when the current was not available. (C. J. Wharton in a paper before the Institution of Engineering Inspection; abstracted through *World Power*, vol. 9, no. 53, May, 1928, pp. 256–260, 4 fig., *d*)

The Low-Range Reflex-Ordinate Boiler-Efficiency Diagram

THE PURPOSE of this diagram is to permit determination of the thermal efficiency of boilers without the use of steam tables or slide rules. It is applicable either to saturated steam or superheated steam and is based on Callendar's enlarged steam tables.

The method of operation of the diagram is simple, as a casual examination will show, but two examples are given below: (Figures in brackets are the points followed by the chain-dotted guide line.)

1 *Saturated Steam.* Starting at the junction of the required pressure line (200 lb. per sq. in.) with the saturation curve, rise or drop vertically to the feed temperature (150 deg. fahr.); now move horizontally from this point to the calorific value of the fuel (10,400 B.t.u. per lb.); drop or rise from here to the line representing the pounds of steam produced per pound of fuel burned (6.80) and, finally, travel horizontally to the right-hand ordinate of the diagram, which will show the efficiency to be 71.15 per cent.

If this example is worked out, using Callendar's enlarged steam tables and a 20-in. slide rule, the result obtained is 71.2 per cent.

2 *Superheated Steam.* The graph's use with superheated steam differs only in that the start is made from the steam temperature on the left-hand ordinate. From this point, travel horizontally to the given pressure, and then the procedure is exactly the same as before.

Many uses of this diagram may be found apart from the use for which it was originally intended. For instance, it is often desirable to be able to say whether a boiler is doing its full work, or whether it is relying too much upon the superheater and economizer to bring up the overall efficiency. This chart will do this much more quickly than the long method, and almost as accurately. For instance, using the following:

Steam temperature	(2)
Water inlet to economizer	(3)
Water inlet to boiler	(4)

First get the efficiency by diagram using (1), (2), and (3), then repeat using (4) instead of (3). The difference is obviously the saving effected by the economizer. To get the saving made by the superheater, neglect (2) and use the graph as if there were no superheater, then subtract the result from the overall efficiency already obtained. (H. C. Golder and R. B. Page. *The Power Engineer*, vol. 23, no. 266, May, 1928, pp. 204, 209, and diagram opposite p. 204, *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

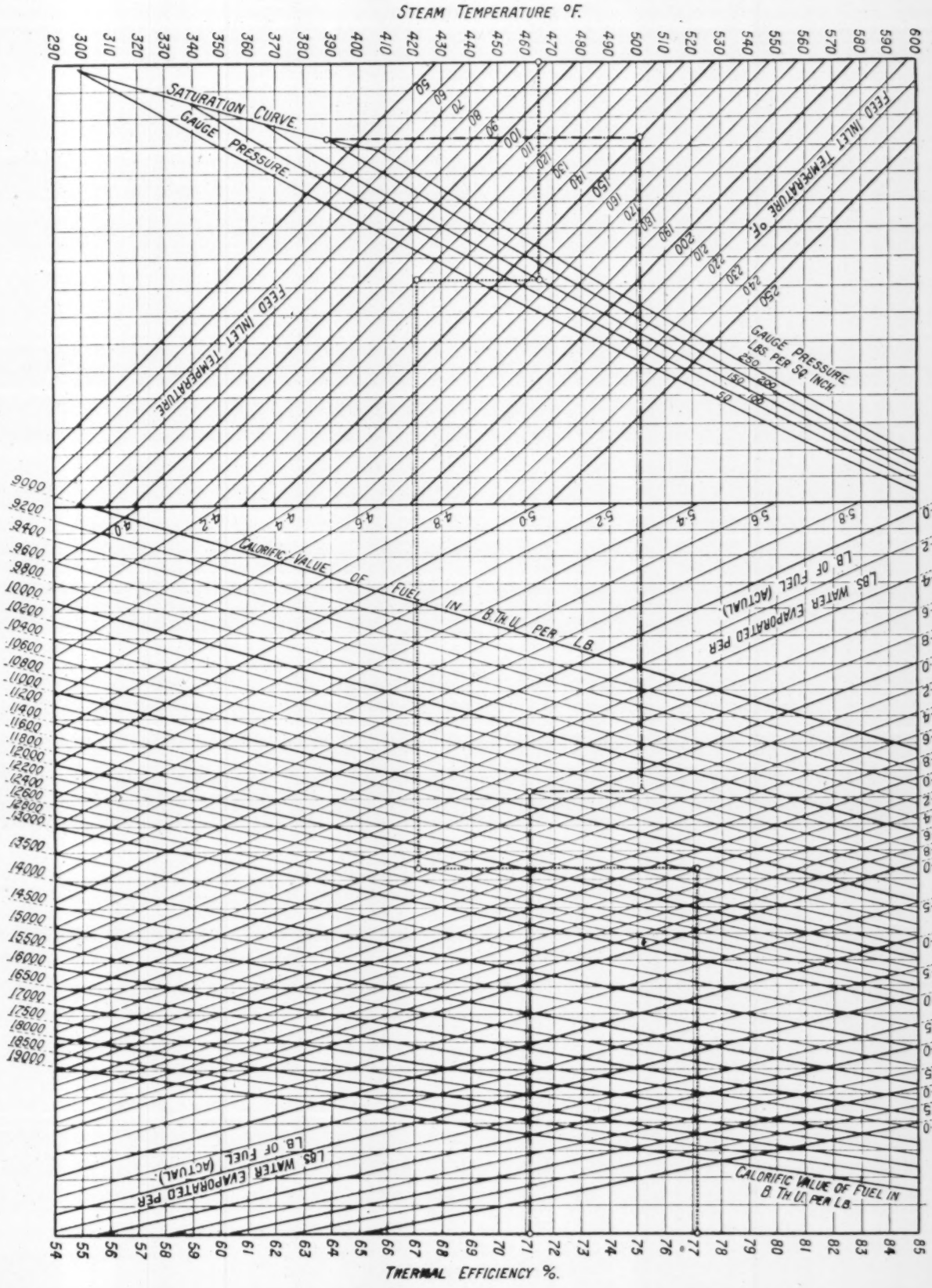

STEAM TEMPERATURE °F.
SATURATION CURVE
GAUGE PRESSURE
FEED INLET TEMPERATURE
FEED INLET TEMPERATURE °F.
GAUGE PRESSURE LBS PER SQ INCH
CALORIFIC VALUE OF FUEL IN B TH U PER LB
LBS WATER EVAPORATED PER LB OF FUEL (ACTUAL)
THERMAL EFFICIENCY %.

FIG. 12 LOW-RANGE REFLEX-ORDINATE BOILER-EFFICIENCY DIAGRAM

Engineering and Industrial Standardization

Mathematical Symbols

THE American Standard for Mathematical Symbols is the first to be completed of a group of nine being prepared by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations which was organized under the procedure of the American Engineering Standards Committee as the culmination of a series of efforts on the part of the A.S.C.E., A.S.T.M., A.I.E.E., S.P.E.E., A.S.M.E., and other national organizations. The societies which accepted joint sponsorship are the A.A.A.S., A.S.C.E., A.I.E.E., S.P.E.E., and the A.S.M.E. This Sectional Committee consisting of representatives of thirty-four national societies, associations, and government departments held its organization meeting on January 21, 1926, and Sub-Committee No. 6 was appointed to report upon mathematical symbols.

This sub-committee held its organization meeting May 1, 1926. Its report was submitted to the Sectional Committee under date of January 22, 1927. After approval by the Sectional Committee the report was submitted to the sponsors under date of June 3, 1927. In due course approval was voted by all five sponsors.

The proposed standard was submitted under date of December 5, 1927, to the American Engineering Standards Committee for approval and in January, 1928, was approved as an "American Standard."

The officers of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations are: J. Franklin Meyer, Chairman, Sanford A. Moss, Preston S. Millar, Secretary, S.McK. Gray, Assistant Secretary.

The members of Sub-Committee No. 6 on Mathematical Symbols are: Edward V. Huntington, Chairman, R. M. Anderson, V. Bush, A. Cohen, R. M. Foster, E. R. Hedrick, A. E. Kennelly, D. Lambert, E. J. Miles, H. B. Reynolds, Chester Snow, V. S. von Szeliski, O. Veblen, and A. P. Wills.

The sub-committees of this Sectional Committee are now developing symbols and abbreviations for the following eight subjects: Aeronautics, Electrotechnics including Radio, Heat and Thermodynamics, Hydraulics, Mechanics, Structural Engineering and Testing Materials, Navigation and Topographies, Photometry and Illumination, Scientific, and Engineering Terms.

Mathematical Symbols

Arithmetic and Algebra

1. $=\ \neq\ +\ -\ \pm\ \mp\ <\ >\ \leqq\ \geqq$ ( ) [ ] % ∞ $\backsimeq$ (for approximately equal to)
2. $a \times b = a \cdot b = ab$; $a \div b = a/b = \frac{a}{b}$ (Influence extends to next + or −). Thus, $a - b/c - d$ should not be used for $(a - b)/(c - d)$. Note that $\frac{a}{b}$ is difficult to print in running text.
3. $a/b = c/d$ for proportion. Discourage $a:b::c:d$.
4. Notation by powers of 10 for very large or very small numbers is recommended; as 3.140×10^9 and 3.140×10^{-6}. The notation 0.0^3314 is useful in tables, to indicate that there are five zeros after the decimal point.
5. In writing numbers having a large number of digits, half-spaces may well be used instead of commas to separate groups of digits. In writing decimals, the 0 before the decimal point should not be omitted (except in tables).
6. $|x|$ = absolute value of x. $x! = 1 \cdot 2 \cdot 3 \cdots x$. Discourage $\lfloor x$.
7. $\sqrt{x} = +\sqrt{x}$, not $\pm\sqrt{x}$ (x being real and positive). $a^{1/n} = \sqrt[n]{a}$. $a^{-n} = 1/a^n$. $\exp x = e^x$ is useful when x is a complicated expression. Note that the bar or vinculum after the $\sqrt{}$ is very expensive to print.
8. When $\log x$ is ambiguous, use $\log_{10} x$ or $\log_e x$. The notation $\ln x$ may be mentioned as an alternative for $\log_e x$.
9. $P(n, r) = n(n-1)(n-2)\cdots(n-r+1)$
   $C(n, r) = [n(n-1)(n-2)\cdots(n-r+1)]/[1 \cdot 2 \cdot 3 \cdots r]$ = binomial coefficients.
   A common alternative for $C(n, r)$ is $\binom{n}{r}$; this however, is difficult to print in running text.
10. $a \propto b$ (meaning a varies directly as b).

Elementary Geometry

11. $\angle\ \triangle\ \|\ \perp\ \odot\ \square\ \cdot$

Analytic Geometry

12. x, y, z; ξ, η, ζ; rectangular coordinates. Right-handed system preferred.
13. ρ, s = intrinsic coordinates. ρ = radius of curvature, s = length of arc.
14. $l = \cos\alpha$, $m = \cos\beta$, $n = \cos\gamma$, direction cosines.
15. r, θ = polar coordinates. ψ = angle from radius vector to tangent.
16. r, θ, ϕ = spherical coordinates. θ = co-latitude, ϕ = longitude. (Usage general in mathematical physics; other notations are used in astronomy.)
17. r, θ, z = cylindrical coordinates. (Usage diverse.)
18. Conics: e = eccentricity. p = semi-latus rectum (usage general in U. S.).
19. Straight line: $y = mx + b$.

Trigonometric and Hyperbolic Functions

20. $^\circ\ '\ ''$ $\sin x$, $\cos x$, $\tan x$, $\operatorname{ctn} x$, $\sec x$, $\csc x$.
21. $\sin^{-1}x$ = the principal value of the angle whose sine is x (x is real). Thus, $-\pi/2 \leqq \sin^{-1}x \leqq \pi/2$, $0 \leqq \cos^{-1}x \leqq \pi$, $-\pi/2 \leqq \tan^{-1}x \leqq \pi/2$. (Discourage arc $\sin x$).
22. $\sin^2 x$ for $(\sin x)^2$ is an exceptional notation, justified by usage. Similarly for $\cos^2 x$, etc.
23. $\sinh x$, $\cosh x$, $\tanh x$, $\operatorname{ctnh} x$, $\operatorname{sech} x$, $\operatorname{csch} x$.
24. $\cosh^{-1}x$ = the principal value (when x is real). (Discourage arc $\sinh x$).
25. $\sinh^2 x$ for $(\sinh x)^2$ is an exceptional notation, justified by usage. Similarly, $\cosh^2 x$, etc.
26. In general f^{-1} means the inverse of the function f; and f^2 denotes iteration of the functional operation. But in exceptional cases, f^2 may denote the square of the function f (as in $\sin^2 x$ and $\sinh^2 x$). In general, $[f(x)]^{-1} = 1/f(x)$.

February, 1928

REPRODUCTION OF A TYPICAL PAGE OF THE STANDARD FOR MATHEMATICAL SYMBOLS

Quality Control in Manufacture

THE Bell Telephone Laboratories have published a paper by Dr. W. A. Shewhart on "Quality Control" that will be of interest to all mass-production organizations having the problem of manufacture of a controlled product through the use of specifications, standards, and systematic inspection. A controlled product is defined as one for which frequency of deviations from expected quality can be estimated by a certain probability theory provided no assignable causes of variations are present. The paper deals with the methods for determining whether or not the product is "controlled" so that the presence of assignable causes of variation can be detected. When such assignable causes making for a divergence from the probability form of the curve of quality or deviations from ideal accuracy of manufacture are known to be present, it generally becomes comparatively simple to find and eliminate them. By this method we achieve the production of a controlled product, which usually calls for less inspection and gives the lowest manufacturing cost. The paper further provides a basis for comparing the quality of output of different factories whether they be subsidiary or merely

plants manufacturing the same kind of apparatus or selling the same kind of goods. The author of this paper, Dr. Shewhart, would be pleased to receive criticisms from those who read it in the light of their own technical problems of control.

Simplified Practice Recommendation for Coated Abrasive Products Adopted

A SIMPLIFIED practice recommendation for coated abrasive products was recently adopted at a general conference held at the Department of Commerce, Washington, D. C., under auspices of the Division of Simplified Practice.

This recommendation provides that certain sizes and varieties of abrasive paper and cloth will be manufactured as stock items after September 1, 1928, which will, according to estimates given at the conference, care for at least 95 per cent of the trade. The conference set the first revision date for the recommendation for July 1, 1929, and allowed until January 2, 1929, to clear the present manufactured stock. It was brought out in the meeting that the present Federal Specifications Board specifications for coated abrasive products conforms with the recommendation adopted.

Manufacturers present at the conference reported the estimated annual output of this commodity as amounting to $16,000,000 and that for a number of years the number of sizes and varieties of abrasive cloth and paper has been increasing at a rapid rate. The conference generally agreed that the recommendation would prove an economic benefit to manufacturers, distributors, and users alike.

Sponsorships Assigned for Electrical Rotating Machinery Standards

AT ITS March meeting the A.E.S.C. accepted the recommendation of the Electrical Advisory Committee and named the American Institute of Electrical Engineers and the National Electrical Manufacturers Association as joint sponsors for

Standards for Direct-Current Rotating Machines—C 23
Standards for Alternators, Synchronous Motors, and Synchronous Machines in General—C 24
Standards for Induction Motors and Induction Machines in General—C 25
Standards for Fractional-Horsepower Motors, Direct and Alternating-Current—C 26
Standards for Electric Arc Welding Apparatus—C 31
Standards for Resistance Welding Apparatus—C 32.

The assignments were made with the understanding that on account of the extent to which it will facilitate the work, the administration of the sponsorship and its chairmanships of the sectional committees be in the hands of representatives of the American Institute of Electrical Engineers.

Standards Notes

"SCIENTIFIC Purchasing," by E. T. Gusheé (Purchasing Agent, Detroit Edison Company) and L. F. Boffey (Editor, *The Purchasing Agent*), has just been published by the McGraw-Hill Book Company. This book deals with many questions not hitherto presented in an adequate manner in books on purchasing, and gives particular treatment to the problem of specifications, proper inspection, and the need for standardization within the company, as means to elimination of waste.

Small Tools and Machine Tool Elements (B 5b-1928). Printer's proofs have been received of the proposed standard for toolholder shanks and tool-post openings, developed under the direction of the sectional committee on small tools and machine-tool elements. The sub-committee on this subject has broad representation consisting of 16 members representing manufacturers and large users. Material developed by the committee was released for criticism in August, 1926, and the present standard represents the results of criticisms received at that time and a subsequent questionnaire sent out in July, 1927. A copy of the proposed standard is available for reference by sustaining members who may be interested.

Safety Codes as Standards of Inspection for Insurance Companies. At a meeting held in May the National Association of Mutual Casualty Companies' Governing Committee approved the recommendation of their Engineering Committee that they endorse the principle of using safety codes issued by the American Engineering Standards Committee as standards of inspection for insurance companies. When such codes have been approved by the Engineering Committee of the Association, and the member companies so advised, they will become standards for inspection for conditions covered by the codes.

NEW AMERICAN STANDARDS

The following standards were approved by the A.E.S.C. during the month of June 15–July 15, 1928:

Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation. (American Standard.)

Sponsored by the A.E.R.A., A.I.E.E., A.R.E.A., A.S.T.M., A.R.E.E., N.E.L.A., N.E.M.A., A.E.I.C., N.B.F.U., and N.F.P.A. Can be purchased upon application to the A.E.S.C., 29 West 39th Street, New York, N. Y.

Specifications for Soft or Annealed Copper Wire. (American Standard.)

Sponsored by the A.E.R.A., A.I.E.E., A.R.E.A., A.S.T.M., A.R.E.E., N.E.L.A., N.E.M.A., A.E.I.C., N.B.F.U., and N.F.P.A. Can be purchased upon application to the A.E.S.C., 29 West 39th Street, New York, N. Y.

Specifications for Portland Cement. (American Standard.)

Sponsored by the A.S.T.M. Published by the A.S.T.M.

Correspondence

Yankee Ingenuity

TO THE EDITOR:

What is Yankee Ingenuity? It seems to me that the correspondents define "ingenuity" but neglect the word "Yankee." I never heard the phrase used except when the device brought a smile to those who saw it for the first time. Isn't it a smile that differentiates Yankee ingenuity from other kinds of ingenuity?

To bring the smile, the device must be puzzling for a moment, and then its usefulness and simplicity flashes out. In commerce it is a self-seller.

GILBERT S. WALKER.[1]

Pittsburgh, Pa.

[1] Consulting Engineer. Mem. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.,
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Applied Mechanics

Acceleration of Water Flow Through an Orifice[1]

AM-6 If a vessel of considerable area filled with water has a very small orifice at a depth H below the surface of the water and this small orifice is opened in zero time, what time will be required for the velocity of the water issuing from the orifice to equal $\sqrt{2gH}$?

The velocity will never reach $\sqrt{2gH}$, nor will it approach that exact value as a limit. Instead, starting at zero, it will increase with time according to a complex law of relationship, and will approach, but theoretically never attain, the magnitude at which the frictional resistances exactly counterbalance the flow-impelling force of gravity. A common value for this limiting magnitude is about 98 per cent of $\sqrt{2gH}$.

Generally speaking, the law of relationship mentioned above is defined by the requirement that at any particular instant the acceleration must equal the net flow-accelerating force divided by the mass of water accelerated—the net flow-accelerating force being the flow-impelling force of gravity less the frictional resistances. However, to calculate the exact numerical values of the acceleration or the velocity at any particular instant on the basis of actualities would be tremendously difficult, if not impossible, because it would involve consideration not only of the flow in the orifice but also of the complex complementary movements of water in the vessel. Furthermore, such calculation would require experimental data not now available as to frictional resistances, and as to directions and magnitudes of movements in the orifice and in the vessel.

However, the writer suggests the following solution, which he believes gives approximately correct results. Consider that each unit of water discharged through the orifice must be replaced by a similar unit from above; that the replacing unit must in turn be similarly replaced by a third; and so forth, on up to the surface of the water in the vessel. A filament of water having a cross-section equal to that of the orifice and a length equal to the head would thus move, and substantially no other movement would take place. This simple hypothetical system is readily susceptible of approximate analysis in accordance with the principles enunciated in the preceding paragraph, as follows:.

Let g = acceleration due to gravity (assumed to be 32.17 ft. per sec. per sec.)
H = head on the orifice
v = velocity of the water in the orifice at any instant; the limiting maximum value of v is assumed to be $0.98\sqrt{2gH}$
M = mass of the moving water column
W = flow-impelling force of gravity; i.e., the weight of the moving water column; $(W = Mg)$
F = frictional resistances (assumed to vary as the square of the velocity); at the limiting maximum velocity, $F = W$
A = net flow-accelerating force; $(A = W - F)$
a = acceleration of the water in the orifice at any instant; $(a = A \div M)$
c = a constant
t = a time interval, and
v_0 = velocity of the water in the orifice at the beginning of the time interval t.

Since the frictional resistances are assumed to vary as the square of the velocity, we have

$$F = cv^2 \qquad [1]$$

In order to evaluate c, substitute in Equation [1] the known values of F and v for the limiting maximum velocity:

$$W = Mg = c(0.98\sqrt{2gH})^2$$

Solving for c,

$$c = \frac{M}{1.921H}$$

Substituting in Equation [1] gives the following general expression for F at any given v:

$$F = \frac{Mv^2}{1.921H}$$

Now

$$A = W - F = Mg - F = M\left(g - \frac{v^2}{1.921H}\right)$$

Therefore, since $a = A \div M$, we have:

$$a = g - \frac{v^2}{1.921H} \qquad [2]$$

[1] This subject has been discussed in a previous issue.

The accelerations during consecutive time intervals, and the resulting velocities, are now determined by trial applications of Equation [2]. This is done by assuming a trial velocity at the end of the interval, solving Equation [2] for a, noting (from the equation $v = v_0 + at$) whether such computed acceleration would result in the velocity assumed, and if not, then repeating the process with a different assumed trial velocity until the assumed and computed velocities agree. The approximate computation for a head of one foot are briefed in the following table:

Time interval, sec.	Total elapsed time, sec.	Velocity at end of interval, Ft. per sec.	Velocity at end of interval, Per cent of limit	Acceration during interval, ft. per sec. per sec., Final	Acceration during interval, ft. per sec. per sec., Mean
0.05	0.05	1.58	20.1	30.9	31.5
0.05	0.10	3.04	38.7	27.4	29.2
0.05	0.15	4.29	54.6	22.6	25.0
0.05	0.20	5.30	67.5	17.6	20.1
0.1	0.3	6.64	84.5	9.2	13.4
0.1	0.4	7.32	93.1	4.3	6.8
0.1	0.5	7.63	97.1	1.9	3.1
0.1	0.6	7.77	98.8	0.8	1.4
0.1	0.7	7.83	99.6	0.3	0.6

It will be seen from the above table that for a head of one foot the time intervals necessary for the water in the orifice to attain velocities of 0.5, 0.9, and 0.99, for example, of the limiting maximum velocity will be approximately 0.13, 0.35, and 0.62 sec., respectively. For other heads, the corresponding time intervals will equal the above values multiplied by the square root of the head.

The above analysis gives the time interval theoretically required for the velocity to increase to within a negligible differential of the limiting maximum velocity. As a matter of fact, in any practical case the velocity will actually reach the limiting maximum within a finite time, usually shortly after it approaches closely to the maximum, on account of the surges which are ever present in flowing water. (Ralph R. Randell, Engineer, Federal Power Commission, Washington, D. C.)

Miscellaneous

OWNERSHIP OF DRAWINGS[1]

M-7 In general, are drawings made in engineers' offices the property of the engineering firm or the client? Give reasons.

The manufacturer naturally is reluctant to give up his original tracings, since they represent his only original record of the design of his product, and since he may be very much in need of specific information when called upon to furnish repair parts or duplicate units.

One manufacturer, to the writer's knowledge, takes care of the customer's demand for tracings by an elaborate equipment for duplicating tracings at low cost by a process resembling hectographing. This appears to be a satisfactory solution of the problem, satisfactory to all concerned. Incidentally, the equipment is convenient when it is desired to prepare designs varying in minor particulars from the original, since the tracing can be duplicated with local omissions at points where variations are planned.

At least one large public utility has developed another solution of the problem, in that they do not require tracings, but do ask for a number of blueprints, at least one or two of them to be printed on cloth. In some cases they receive from the manufacturers one or two Van Dyke negative prints, from which a number of blueprints are readily prepared. This is an inexpensive means of furnishing the customer with complete information, without depleting the manufacturer's records. (C. H. Berry, Associate Editor, *Power*, New York, N. Y.)

[1] This subject has been discussed in a previous issue.

Textile

MANUFACTURING COSTS IN THE COTTON-TEXTILE INDUSTRY

T-3 George Wrigley in his paper on "Power Losses in Cotton Textile Mills," in the November, 1926, issue of MECHANICAL ENGINEERING, gives certain figures on power requirements. Are figures available showing the relation of power to manufacturing costs in the cotton-textile industry in this country?

Some local print-cloth mills show the following figures for one-month's records.

Relative cost of power to total cost of production,
two different months ..... { 9.9 per cent / 8.8 per cent
A local fine-goods cloth mill showed ..... 7.8 per cent

The percentage of power cost to manufacturing cost would be increased for coarse goods and would be increased for yarns.

The above costs are for purchased electrical power. Mills operating their own steam plants for local generation of power keep their accounts in somewhat different shape, and in such cases the cost of power would be about 5 per cent of the total manufacturing costs.

Looked at from the present-day standpoint, it is believed that 8 per cent to 12 per cent would be more nearly representative of the country at large and including all classes of goods than would be the figure of 6 per cent previously given. (George Wrigley, Electrical Engineer, J. E. Sirrine & Co., Greenville, S. C.)

Questions to Which Answers Are Solicited

COAL FOR STOKER PRODUCING INSUFFICIENT AGITATION

F-12 On a New England single-retort underfeed-stoker installation, the maximum mechanical adjustments possible still do not permit sufficient agitation to keep porous the fuel bed of the New River nut and slack used. Suggestions are solicited as to the names of specific semi-bituminous (or "smokeless") mines commercially adjacent for tidewater shipments, producing the least caking, most free-burning coal possible for semi-bituminous. High ash fusion and form factor producing a minimum of dust are, of course, also desirable.

TEMPERATURE AS RELATED TO FRICTION

M-8 What relation exists between friction and temperature in the case of two metal specimens in sliding contact under unlubricated conditions?

REPAIR COSTS

MG-2 What is a reasonable figure for yearly repair costs of lathes, milling machines, planers, etc., as a percentage of the original cost of the machines?

RAILROAD CLEARANCE LIMITATIONS

R-3 What, if anything, is being done on present-day railroad construction of terminals, bridges, abutments, etc., toward possible increase of railroad clearance limitations (height and width)?

MAXIMUM AXLE LOADS

R-4 What is the maximum axle load permissible with the usual O. H. steel rails without injury to the metal?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or.... printed in its publications (B2, Par. 3).

Oil-Engine Power Costs

ONE of the stumbling blocks to the introduction of the Diesel engine in competition with other types of prime movers is the lack of accurate cost data from which a prospective user may satisfy himself of the operating expense of this fairly new source of primary power. Sensing this weakness in the position of the Diesel engine, the Oil and Gas Power Division has appointed a Power Cost Committee to gather such data for the good of the Diesel engine industry and for the information of engineers, so that this feature may no longer be shrouded in vague estimates and the prejudices of hope or doubt.

At the Oil Power Conference, held at State College in June and reported elsewhere in this issue, Harlan A. Pratt, in a paper on the small and medium size Diesel engine, which is also to be found in this issue, makes a plea for the submission to this committee of the data it was constituted to bring to light. Engineers will welcome the publication of accurate and intelligible cost data and will heartily endorse Mr. Pratt's plea. When such data are available, there will be much less loose talk for and against the Diesel engine. The committee will earn the gratitude of all power engineers and owners of power plants if it succeeds in bringing out a trustworthy report, but the report will be possible only if operators are willing to cooperate to the extent of supplying the information which they themselves possess.

Search or Research?

WORDS in a living language are continually changing their meanings. Ordinarily, the change is graduated over a considerable period of time, but if the word stands for an important idea which touches the lives of many it will more quickly lose its strength and original meaning.

The human weakness of exaggeration is largely responsible for the debasement of strong words. The strong word is used to clothe a trivial act or idea with a mantle of importance—a private strutting about in the uniform of a general.

The word "efficiency" has gone this route. Once efficiency expressed the purpose of engineering—now it is "fighting talk" to be called an "efficiency engineer."

Research as a word, seems to have started on the same course. The word is already being used to describe inquiries of more or less superficial character. We are beginning to hear this or that collection of data or laboratory routine referred to as "research." This kind of work lacks the fundamental "searching again" for causation that the word research signifies.

Ordinary wear and tear cannot be helped, but is there not a tendency toward deliberate misuse which can be checked?

Stockholders, reading much about research, are wisely beginning to inquire whether the company in which they are part owners is giving due attention to this subject. Is this pressure to result in naming the control laboratory "research laboratory" and the setting up of a "research fund" not so employed, or is it to result in true research activities? The answer will depend very largely upon how well the public is informed as to the nature of research and how promptly and effectively the pretense of research is condemned.

Research means:

> Diligent, protracted investigation, especially for the purpose of adding to human knowledge; studious inquiry.
>
> A systematic investigation of some phenomena by the experimental method to discover facts or to coordinate them as laws.

Let us try to preserve this meaning and keep "research" out of the comic strip.

U. S. Shipping Board Announces Notable Fuel-Conservation Record

THE recent announcement of the Fuel Conservation Committee of the United States Shipping Board of the honor roll and honorable-mention roll of masters and chief engineers of fifty vessels of the Shipping Board fleet making the best showing with respect to fuel economy in the six-month period from July 1 to December 31, 1927, discloses results that should prove extremely valuable and encouraging to all who take seriously conservation of our national fuel resources.

The two rolls were based on analyses of the performance records of a total of 324 vessels which had traveled some 7,134,538 miles, spending 691,747 hours at sea and 551,136 hours in port during the period of the contest. A total mileage of 20,000 miles during the period was the requirement necessary to qualify a vessel.

The reduction in fuel over the period was such that the saving amounted to 155,438 barrels of oil and 970 tons of coal at sea, as compared with the preceding six months. The saving in port amounted to 50,671 barrels of oil and 714 tons of coal. With costs during the period averaging $1.60 per barrel of bunker fuel oil, $1.95 per barrel of Diesel oil, and coal at $6.04 per ton, the saving amounted to $340,619.

One of the most interesting features of the contest, and one that should spur marine engineers and fuel experts to greater activity, is the fact that the fifty chosen vessels were about nine years old and were not equipped with the various fuel-saving devices available today. That it is possible to find fifty nine-year-old vessels upon which such a record can be made when the naturally expected result is a decrease in economy with increasing age, indicates forcibly that much of our present waste of fuel is wholly unnecessary.

Industrial Secrecy

THE attitude of various companies, and indeed of various countries, toward the disclosure of methods, processes, etc., is by no means uniform. In certain industries, as, for example, the automobile, methods of production are freely open to inspection. This is partly due to a recognition of the fact that it is to the advantage of every one in the industry to interchange ideas, and partly to the recognition of the fact that because of the frequency with which workers leave one plant and obtain employment in another, it would be extremely difficult to keep anything secret. This is, however, true only in so far as methods of production are concerned. When it comes to design, and particularly the development of new metals, secrecy more intensive than that at General Headquarters during the war, prevails, as witness the recent well-advertised preparation of the Model-A Ford car.

The same situation in this country prevails in metallurgical plants, particularly in those making steel. General blast-furnace and open-hearth practice is an open book. Managers of open-hearth departments of various companies meet from time to time to exchange very broadly their experiences. In electric-furnace work, particularly in the field of alloys on the other hand, the utmost secrecy prevails, every manufacturer claiming that he has mysterious, secret, and strictly confidential processes which produce marvelous results. Whether this is due to a sincere conviction or to trade policies is a question that need not be gone into here.

On the whole, however, American manufacturers are far less given to secrecy than European. For example, in Germany until quite recently it would have been considered the height of impertinence for an engineer to ask about a process or machine used in a department of the plant other than the one in which he was employed. Admission of engineers of competing companies to look at the plant would have been considered as being absolutely out of the question, and visiting Continental engineers have often on returning home expressed their surprise at being so freely admitted to American plants.

Of late, research has been carried on more extensively and with a better comprehension of its importance than ever before. Quite a large number of manufacturing concerns have either a research department or at least something corresponding to a director of research. Where this is the case, it is becoming more and more the practice to concentrate all new work in one place and to keep visitors out of it as much as possible. One large company engaged in the manufacture of alloys has quite an effective arrangement under which special work is done on certain days, and when these days are decided upon the plant managers and main office are notified and no visitors are admitted. This makes it possible to admit visitors freely on other days and to keep certain information secret, and yet give the impression of having, to speak colloquially, "nothing but their cuffs up their sleeves."

Speaking broadly, with the present rapid change in the development of methods and products, every large concern and many small ones have unquestionably work going on that should not be shown prematurely to outsiders. Because of the increasing intensiveness of foreign competition it may not be a good plan to throw the doors too wide open to visitors from abroad. At the same time, however, it is well to realize that excessive secretiveness in the long run is apt to become a costly proceeding, not only for the whole industry but particularly for the concern practicing it. In many cases the desire to cover up everything indicates merely a lack of confidence in what one has, and, for example, until quite recently the brass-rolling industry was both the most secretive and the least advanced of all the heavy metallurgical industries.

In some industries the idea of utmost secretiveness is so deeply ingrained that manufacturers do not even try to look for information where they might expect to find it, because they are convinced that no one would ever make it public. A rather interesting experience of the present writer bears this out.

At the beginning of the war a certain American concern wanted to make a chemical which up to then had been imported from Germany. Not knowing how to make it, the company sent one of its foremen, a Swiss by birth, to Europe, with a fat traveling account and instructions to bring back full particulars of the method. After about three months the foreman returned and brought what he thought was information on the right process and which he had obtained by visiting the beer gardens in the neighborhood of the chemical plant making that particular product and asking questions. The cost of this ran into several thousand dollars and the process did not work, because apparently some important step not known to the workmen had been omitted. The American company then asked the writer, supposed to be familiar with European methods, to obtain the necessary information, without of course telling him at the time about their previous failure to do so. Deeply impressed with the difficulty of their task they volunteered to name a generous fee for his services. About ten days later they were given the instructions which permitted them to make the desired product quickly and without any trouble. On handing him a check the president of the company asked the writer where he got his information so quickly, considering that his own company had spent thousands of dollars and had not succeeded. He was quite astounded when told that the information in question was obtained at an engineering library in New York City from a German chemical journal in which it was published completely, and had involved no research whatsoever on the part of the writer. He added, however, that he never thought the Germans would be such fools as to publish the information, but was fair enough to state that had his company known it was procurable, they would have been in the business making the product ten years before the war.

There is an important lesson in the above story. The man or concern practicing the utmost secrecy slips much too easily into the frame of mind that no valuable information is publicly available, and that is a dangerous frame of mind in the world of engineering of today. Further, in a large plant where men, both workmen and engineers, come and go, it is impossible to keep everything secret. It is therefore only by selecting a few things that especially deserve to be protected and concentrating all precautions on these few things that it is possible to guard such information as ought not to be broadcast. A hush-hush attitude throughout the plant is generally to be discouraged, and the more open and above board the major operations are carried on, the better can the morale of the plant be maintained and the more confidence the men will have in the management.

Structure of the Atom

IT BEHOOVES the mechanical engineer of today to keep as close a touch as possible on developments in physics bearing on the structure of the atom. This has ceased to be a "high-brow" theoretical speculation without importance to the practical man. As a matter of fact, engineering has already passed the stage where it is dealing only with visible and easily measurable subdivisions of matter. Not more than ten or fifteen years ago even the molecule was a unit of matter so small as to be beyond the ken of the ordinary mechanical engineer. This is no longer true today, and in his everyday work the mechanical engineer is already dealing with atoms, as shown, for example, in a paper by Trillat recently published in abstract in MECHANICAL

ENGINEERING. Phenomena of lubrication cannot be understood, as shown by the work of Trillat himself, Woog, Marcelin, and others, without considering the magnetic fields surrounding the atoms.

In the so-called atomic-hydrogen welding a molecule of hydrogen is broken up into atoms by passing through an appropriate electric arc and it is the recombination of the atoms into the original molecule that generates the heat used in welding. The engineer is not yet dealing practically with sub-atomic phenomena involving the internal structure of the atom itself, but he has already approached it so closely as to make the subject of real practical interest. Flow of current is clearly nothing but an electronic phenomenon and so is the action of a thermionic or a Coolidge tube and certain other devices. In the field of heat transmission and even heat generation sub-atomic phenomena are beginning to be involved.

Because of this, the question of the structure of atoms is becoming of increasing interest. It is a difficult and complicated subject and a surprising amount of ingenuity of the highest order is being used to obtain a clear insight into what is happening in a region which is apparently beyond our present human ability to observe by direct means. Indirect methods of investigation have therefore been adopted and, to interpret them, entirely new mathematical conceptions and methods have been introduced. So rapid is the advance made in this field that many conceptions and theories which seemed to have been fairly generally accepted not more than two or three years ago are today on the scientific scrap heap, and for all we know by the time this editorial is published views which seem to hold good today may already be antiquated. Up to a couple of years ago the Bohr theory of the structure of the atom was thought to present a concept that agreed with available experimental observation and fitted into such theories of matter as were then held. According to Bohr the atom consisted of a central nucleus and a number of electrons, from one to several scores, flying around it on some such scheme as a sun-and-planet motion. This theory has been so modified within the last two years as to become unrecognizable.

In the first place it has been pointed out that while nearly all the attributes of an astronomical model, namely, the sun, planets, and their orbits, have been taken over into the theory of the atom, the important feature of the rotation of the planets about their axes escaped attention. This led to the development of the idea of the spinning electron by Compton, and introduced an element which, as will be shown a little later, made observational investigation of the structure of the atom far more difficult than it would have been otherwise.

Furthermore, as pointed out by Sir Oliver Lodge in his Kelvin lecture of this year, a curious state of things exists. Modern physics aimed at simplifying the former complex ideas as to structure of atom and ether; but instead it detected complexity in what had hitherto been regarded as being simple. In the Bohr atom the electrons were in the corpuscular state of aggregation. This, however, did not concur with certain conclusions drawn from the quantum theory (this is a complicated subject and it is expected that an article explaining it to laymen will be published in an early issue of MECHANICAL ENGINEERING), and deBroglie and Schrödinger have evolved a new theory in which phenomenon we know of as electrons represents a wave structure and not a corpuscular structure. In fact, as physics is developing it would appear more and more that a particle or a wave are not something opposite, but may be two phases of the same unknown phenomenon. It appears now to have been established that a corpuscle in accelerated motion has a wave structure associated with it, while certain kinds of waves have a particle embedded in them.

In arriving at these concepts of the structure of matter in what appears to be the very uttermost edge of subdivision, basically new methods had to be developed. Some of these are mathematical, while others are experimental, and obviously only a very brief mention of either can be here made. Up to the "way-back ages," before 1925, the quantum theory as it was then formulated postulated the existence of stationary states of atoms calculated by the use of the classical mechanics and selected in certain ways. A new mechanic has been developed since, however, and in this the equations have the same form as in the classical theory, but the variables no longer satisfy the commutative law of multiplication, i.e., xy is not necessarily equal to yx. What is more, a new device was introduced so that "half odd integers," i.e., numbers of the structure of $\left(n + \frac{1}{2}\right)$ came to be used as well as integers as the possible values of the quantum numbers. An entirely new scheme of quantum kinematics has been developed incidentally by which the quantum formula would be obtained directly in terms of frequencies and intensities of the spectra which are experimentally observable rather than in terms of magnitudes which cannot be observed. This was capped by an investigation of resonance phenomena in atoms with two electrons, of importance because it gave the key to the solution of the spectrum of neutral helium, and in this way proved for the time being the fundamental correctness of all of this new science.

Experimental confirmation of the theories of structures of the atom have been sought by many of the investigators. One of the most interesting of these is that recently made by Prof. G. P. Thomson of Aberdeen and referred to in the Kelvin lecture of Sir Oliver Lodge mentioned above.

Professor Thomson took a beam of cathode rays and analyzed it by passing it through a very thin film of crystalline matter, so that it was exposed to something akin to diffraction. The result was that, when it was received on a photographic plate, there was an impact surrounded by a ring structure, which was immediately suggestive of "interference," that is, of waves. The only doubt that might arise about the interpretation of this experiment was whether the periodic structure thus displayed was due to the crystal. The answer, no doubt, was that a regular molecular structure could not give an interference pattern as the result of the impact of a mere particle. Such a pattern could only result from the reception of something of the nature of a wave or pulse in a continuous medium. Accordingly, the experiment was a definite demonstration that the theory of the deBroglie and Schrödinger, which postulated a wave structure as an accompaniment of a rapidly flying electron, was well founded. It must also be admitted that details in the theory of such wave structures were confirmed metrically by the measurements made by Professor Thomson, and that there was also as close, or closer, an agreement between theory and experiment as could be expected.

As a matter of fact, experimental work in this field is of an amazing and often contradictory complexity. Take, for example, the matter of the position of the electron. The electron can be illuminated and observed through a microscope. The accuracy with which the position can be observed is given by the wave length of the light used. If we use a γ-ray microscope we should get the most exact result physically possible (Geo. Birtwistle, "The New Quantum Mechanics," 1928), but these γ-rays produce a Compton effect on the electron so that at the instant when the position is determined the momentum of the electron is stationarily changed. This change of momentum is all the greater the shorter the wave length of the light used, i.e., the more accurate the determination of position is—in other words, the better you work, the worse off you are. At the moment when the position of the electron is known its momentum can only be known to an order equal to this discontinuous change. Hence,

the more exactly a coordinate is determined the less exactly can its momentum be found, and conversely. This may appear a little bit involved to an engineer but does not seem to disturb the scientist—much.

I.E.C. Advisory Committee No. 5 on Steam Turbines Meets at The Hague

IN 1906 the International Electrotechnical Commission, which held its first meeting in London as a direct result of the Electrical Congress held in St. Louis in 1904, was organized primarily as an international standardizing body in the electrical field, but as time went on it took up the study of such questions as the rating and testing of prime movers for electrical plants. In July, 1914, it published specifications on the "Nomenclature for Hydraulic Turbines for Electrical Plants."

The World Power Conference in London in 1924 gave an added stimulus to the power-test-code activity. The National Committees of Great Britain, Switzerland, and Germany had developed codes or specifications for water turbines, steam turbines, and internal-combustion engines. In the United States, the U. S. National Committee invited The American Society of Mechanical Engineers to take up membership and to designate the A.S.M.E. Committee on Power Test Codes as the active group in this country on the testing of prime movers. This invitation was accepted and the Society has had an active part in the councils on this subject.

In April, 1926, the Commission met in New York and at the sessions of the Advisory Committee on Prime Movers, the important elements of test codes for water and steam turbines were considered. The various proposals of the several national committees which already had been brought before the Advisory Committee were discussed more or less in detail. The report of the sub-committee on the testing of steam turbines presented at this meeting covered rating, speed regulation, information to be furnished with an inquiry or order, interval between installation and test, tolerances or margins in guarantees, weighted average steam consumption, and method of correcting test data.

The next meeting of the Commission was held in Bellagio, Italy, in September, 1927. At this time, due to the development and expansion of the work of the Advisory Committee on Prime Movers, it was decided to form two distinct committees to be known as Advisory Committee No. 4 on Hydraulic Turbines and Advisory Committee No. 5 on Steam Turbines. It was agreed also that the United States should hold the Secretariat for both these committees. An agreement was reached regarding the tentative draft specification for steam turbines developed but the members of the Advisory Committee felt the need for another meeting to take place prior to the next plenary meeting of the I.E.C. in 1930. This meeting was held during the week of May 20 at The Hague, Holland, to consider a commercial code covering acceptance tests for steam turbines.

The American representatives were Francis Hodgkinson, Irving E. Moultrop, Clarence M. Popp, and Clifford B. Le Page, who served the meeting in the capacity of Assistant Director for the Secretariat for I.E.C. Advisory Committee No. 5 on Steam Turbines. Dr. C. Feldmann, President of the International Electrotechnical Commission and Professor at the Technical University at Delft, Holland, presided as chairman of the meeting. Charles Le Maistre, General Secretary of the I.E.C., also was present.

Specific proposals were submitted for consideration by the British, German, Czechoslovakian, and the United States delegates for Part 2 covering rules for acceptance tests. The British proposals were based on the report of the Institution of Civil Engineers on "Tabulating the Results of Heat Engine Trials," while those of the United States were based on the A.S.M.E. "Power Test Code for Steam Turbines." These various proposals contained a mass of detailed information, and the work of the committee was largely concerned with the task of collating the data available and assembling them into one comprehensive code. In spite of the very specialized and complex nature of the subject, considerable progress was made owing to the strenuous efforts of the three sub-committees which were appointed to deal with specific aspects of the work. To facilitate discussions, the subject was divided broadly into seven sections, it being understood, however, that the final draft proposals for the rules for acceptance tests, when circulated to the national committees for review, will not necessarily retain this rigid subdivision or sequence of sections. The seven sections in question are: object and scope, definitions, guiding principles, essential measurements, instruments and methods of measurement, computation of results, data and results. Some of these sections were discussed in detail, while others were only considered from the point of view of broad principles, the drafting of the detailed proposals being left to the U. S. National Committee as Secretariat, in collaboration with an editing committee consisting of one delegate each from France, Germany, Great Britain, Switzerland, and the United States.

This second part of the international document is by agreement strictly limited to those observations necessary to determine if the contract guarantees are limited to capacity, heat rate, steam rate, and governor performance. This new document for Part 2, to be known as "Rules for Acceptance Tests" of a complete I.E.C. document on steam turbines will contain few terms and observations as compared with a complete test code.

The delegates voted to recommend that another meeting of the Advisory Committee be held next spring or early summer to expand the work done at Bellagio, and to revise and confirm the commercial code for acceptance tests as drafted by the Secretariat, and also to consider the need for a complete technical code.

Boulder Dam Commission

A COMMISSION of engineers and geologists whose duty it will be to study and report on the Boulder Dam in accordance with a resolution of Congress has been appointed, according to an announcement on July 7 of the Secretary of the Interior. The commission is composed of the following: William L. Siebert, major-general, U. S. Army, retired; D. W. Mead, professor of hydraulic engineering, University of Wisconsin; Robert Ridgway, chief engineer, Board of Transportation, New York, N. Y., and former president of the A.S.C.E.; Charles P. Berkey, professor of geology, Columbia University; and W. J. Mead, geologist, university of Wisconsin.

It was announced by the Secretary that in making these selections, the eminence in his profession of each man was considered, and those were chosen who had no personal interest, residence in, or intimate knowledge of the area within which the dam is projected. Under a joint resolution adopted at the last session of Congress, it will be the duty of the commission to examine the proposed site, to study the plans and estimates which have been made in connection with the project and to report on "matters affecting the safety, the economic and engineering feasibility, and the adequacy of the proposed structure and incidental work."

Readers of MECHANICAL ENGINEERING will recall that in the June issue, Dr. W. F. Durand, professor emeritus of mechanical engineering at Stanford University, discussed the Boulder Dam project in an article entitled "The Colorado River Problem." Attention is also called to the fact that D. W. Mead of the newly formed commission contributes to this issue a paper entitled "Problem of Storage for Flood Control."

Institution of Civil Engineers Celebrates Centenary of Its Charter

FROM June 3 to 7, the Institution of Civil Engineers of Great Britain celebrated the Centenary of the Royal Charter which it received in 1828. Plans had been laid for the celebration in 1918 of the one-hundredth anniversary of the founding of the Institution but the World War made such a celebration impossible.

The celebration was made the occasion of one of the periodical engineering conferences which the Institution has held since 1897 and to it were invited delegates of engineering, scientific, and professional societies and universities in all parts of the British Empire and in most of the civilized countries of the world. Papers of broad scope on important subjects were presented to the conference.

Sir James Alfred Ewing delivered the thirty-fourth James Forrest Lecture on June 4, having for his subject "A Century of Inventions." The text for this address was taken at the suggestion of the Council from a prediction which Thomas Tredgold added to the definition of civil engineering which he drew up for the petition for the Royal Charter, presented in 1828: "The scope and utility of Civil Engineering will be increased with every discovery in philosophy, and its resources with every invention in mechanical and chemical science."

The speaker visualized what engineering meant in 1928 and its relation to the science of the day. Engineers of that period were mainly concerned with roads, bridges, and canals, he said. This was followed by the introduction of the railroad which became necessary when the extent to which canals were used indicated their inadequacy. The steam engine originally used for pumping water out of mines had been adapted by Watt and his followers to driving the machinery in factories and had become a powerful factor in the industrial revolution. Although a prejudice against the use of high-pressure steam existed, Jacob Perkins had exhibited, even before 1828, a piece of steam artillery, which under the pressure of 65 atmospheres projected nearly 1000 musket balls per minute. Carnot had already written his essay on heat.

Sir Alfred next called attention to the technical literature of that period, which was indeed inadequate for the early student of engineering. Both physicist and engineer alike, he said, were groping their ways amid the confusion which existed and the engineer particularly was trying to avoid the use of mathematics in his analysis. The fundamental sciences of mechanics, heat, and electricity, he pointed out, were also in their infancy. The engineers' ability to measure was handicapped by the lack of precision which existed in such fundamental aids as the plane surface, the true straight edge, and the satisfactory screw. The properties of steam had not been investigated, he said, until Regnault undertook researches which led to publication, in 1847, of tables of data.

Sir Alfred then dwelt on some of the developments which have come in various branches of engineering, such as naval architecture, the aeronautical sciences, and research.

In an inspiring peroration Sir Alfred called thoughtful attention to the future, and to the responsibility of engineers to educate mankind in the useful and creative, rather than the destructive, possibilities of the tools he has placed in the hands of society.

In connection with the celebration a conversazione was held on the evening of Tuesday, June 5. Numerous exhibits of engineering models were displayed which appropriately illustrated the developments in civil-engineering works since 1818.

Exhibits provided by the Metropolitan Water Board included a section of elm water main used in London prior to 1808. Portions of lead water mains of the late 16th century, and of early cast-iron spigot and socket mains, jointed with wooden staves, were also shown.

A collection of ancient and modern apparatus used in connection with coast and channel lighting was displayed by the Elder Brethren and there were also exhibits of ship models loaned by The Science Museum, and by Sir John Thornycroft.

An exhibit provided by Mr. Charles J. Brown showed samples of angle rails and fish-bellied rails on stone sleeper blocks in comparison with a section of the present standard track of the London and North Eastern Railway system. Other railway exhibits were models of early and modern locomotives.

Sir Robert A Hadfield arranged an interesting exhibit illustrating the progress in the development and application of alloy steels, and Mr. S. O. Cowper-Coles showed a model of his process for rendering iron and steel rust-proof.

There were a few exhibits illustrating the development of power-production appliances including a model of Maudslay's table engine of 1807 and a Gramme dynamo and a Siemens dynamo of 1870 and 1873, respectively.

Professor E. G. Coker showed apparatus demonstrating the analysis of stresses in structure by means of glass models and polarized light, and Messrs. J. S. Wilson and W. Gore showed rubber models and auxiliary apparatus used by them early in the present century in determining the stresses in masonry dams.

Many interesting books and manuscripts from the institution library were also on view, including the minutes of the first meeting, an early account book, and the original record of Tredgold's description of a civil engineer.

The activities of the Institution were described by its President, E. F. Trench.

The history of the Institution of Civil Engineering has been an honorable one in the development of modern civilization. For 96 years it held meetings every week and it was not until the outbreak of the recent war that these were held every fortnight. In the early days, it was necessary to fine members of the Institution who failed to present papers, in order to stimulate a sufficient production in engineering literature to satisfy the ambitions of the Institution. This method has been abandoned as the number of engineers belonging to the Institution has increased, and the practice of giving medals and awards for exceptionally brilliant papers has been adopted.

The Institution early recognized its responsibility toward the younger engineer and established in 1838 a class of graduates which in 1867 was replaced by one of students. In 1889, it prescribed certain examinations to be passed by students; in 1897 it instituted examinations to be passed by associates, and in 1919 an examination in routine office work of the civil engineer.

The Institution has fostered many fundamental researches and scientific investigations of engineering problems. It has cooperated with other institutions like the mechanical and electrical engineers, the naval architects and the Iron and Steel Institute. It operates its own benevolent fund, supported by voluntary subscriptions, from which in the last 64 years more than a million dollars has been distributed with the strictest possible privacy.

In number, the Institution has grown from the "full 100 members" of 1826 to more than 10,000 at the present time.

Engineers in this country and the world over owe an inestimable debt to the Institution of Civil Engineers of Great Britain.

Diesel Engines Discussed at State College

Interest in Diesel Fuel Oil Specifications, Research, and Specialty Manufacture Crystallized In Important Actions Taken at Second Annual Oil Power Conference

THE Diesel engine was the subject of the First National Meeting of the A.S.M.E. Oil and Gas Power Division held in connection with the Second Annual Oil Power Conference at The Pennsylvania State College, State College, Pa., June 14 to 16. In the total registration of 300, the names of representatives of Diesel engine builders gave a gratifying indication of the interest of the manufacturer in the proceedings of the Conference.

State College makes an ideal place for a Conference. In the midst of a beautiful campus which is situated in the picturesque Nittany Valley, 1200 feet above sea level, members of the Conference were able to enjoy a relaxation from their customary duties in an ideal atmosphere. Accommodations were found in the college dormitories and meals were served at the college commons.

The Technical Sessions

The technical sessions developed an unusual amount of interest and discussion, and in spite of the perfect weather and nearby golf links, the attendance was always large.

President Ralph D. Hetzel of The Pennsylvania State College presented the address of welcome at the opening session on Thursday morning, F. G. Hechler, Professor of Engineering Research at the college being in the chair. Fred R. Low, Past-President, A.S.M.E., then assumed the functions of presiding officer and introduced Colonel Oliver F. Allen of the International General Electric Company whose abundantly illustrated report on "European Diesel Engine Development" was most enthusiastically received. A vote of thanks was extended to Colonel Allen and to the European manufacturers whose assistance in supplying data and illustrations of their practice made possible the extremely interesting and valuable presentation.

The afternoon session devoted to economics was presided over by R. L. Sockett, Dean of the School of Engineering. Three papers drew forth considerable discussion; H. A. Pratt, manager of the oil-engine department of Ingersoll-Rand Co., spoke on "The Economic Field for Small and Medium-Size Diesel Engines." His paper is printed elsewhere in this issue, and contains a plea for submission of oil-engine cost data to the Power Cost Committee of the Oil and Gas Power Division. A paper by E. B. Pollister, general manager, Busch-Sulzer Bros. Diesel Engine Co., entitled "The Economic Field for Large Diesel Engines," was read by C. E. Beck of the same company. Roswell H. Ward, managing editor of *Motorship*, New York, spoke on "The Diesel Engine and the Public Utilities." The papers provoked a large amount of discussion which was opened by Edgar J. Kates, consulting engineer, New York, chairman of the Oil and Gas Power Division.

Friday morning's session was a conference on Diesel fuel oil specifications at which G. H. Michler presented a plea for action in standardizing such specifications. After an interesting discussion in which many points of view were expressed and which was lead by Commander J. J. Broshek, U. S. Navy, O. H. Wiese, senior engineer of the U. S. Shipping Board, and Ernest Nibbs, chief engineer of the New London Ship and Engine Co., a resolution was passed referring the matter to the regularly constituted agencies in the Society which sponsor such standards. G. L. Wendt, Dean of the School of Chemistry and Physics of The Pennsylvania State College, presided.

Because of the showing of the motion pictures taken by the Japanese Aeronautical Institute at a rate of 20,000 per second, the session on Research was held on Friday afternoon at the local theatre. Following the presentation of the film, Harte Cooke, of the McIntosh & Seymour Corp. and chairman of the Survey Committee, A.S.M.E., Oil and Gas Power Division, read a paper on "Cooperative Oil Engine Research" in which he called for some definite action in this field. P. H. Schweitzer, Associate Professor of Engineering Research at the Pennsylvania State College, described the work under his charge in a paper entitled "Penn State Oil Spray Research." R. J. S. Pigott, chairman of the Main Research Committee of the A.S.M.E., explained the steps necessary in undertaking a research problem and the very practical need for money. It was voted that the Oil and Gas Power Division support oil-spray research and the Divisions' committee was instructed to proceed actively in a program of cooperative research. G. W. Lewis, Director of Aeronautical Research, Advisory Committee for Aeronautics, presided.

Saturday morning was devoted to a Symposium on Specialization in Oil-Engine Manufacture. The presiding officer was Edgar J. Kates, chairman of the Oil and Gas Power Division of the A.S.M.E. There were two papers, one by O. D. Treiber, president, Treiber Diesel Engine Corp., and the other by C. R. Alden, chief engineer of the Ex-Cell-O Tool Mfg. Co. Mr. Treiber suggested that the A.S.M.E. could contribute a factor of tremendous economic value by forming a committee to study the standardization of certain engine parts such as fuel-pump plungers and valves with a view to specialized manufacture as well as interchangeability. Chairman Kates assured the Conference that this suggestion would receive the active attention of the Society.

Conference Action Already Bearing Fruit

The three important fields of activity which were surveyed at the Conference and in which definite suggestions were made for action by the Society were cooperative research, Diesel fuel oil specifications, and specialty manufacture. The Oil and Gas Power Division, cooperating with the Society's regularly constituted committees and headquarters staff, is already engaged in carrying out the recommendations of the Conference. Progress will be reported in these columns from time to time.

The Exhibits

In spite of the full programs of the technical sessions, there was plenty of time to visit the laboratories of the college and to inspect the exhibits which were on display. In addition to the regular equipment of the college, several accessory manufacturers had arranged for exhibits of their products. Dr. De Juhasz displayed his high-speed indicator attached to a Buick automobile engine. The oil-spray research attracted considerable attention. Professor Schweitzer and his assistants explained the apparatus and its operation with great patience and care and demonstrated the action of the spray by means of the stroborama. Harold M. Jacklin, Associate-Professor of Automotive Engineering, Purdue University, Lafayette, Ind., also exhibited a high-speed indicator of his own design installed on his automobile which he had driven to the Conference from Indiana.

Social Events

There were about thirty ladies attending the Conference and,

with their hostesses, they added greatly to the success of the social events and the pleasant times which marked the evenings of the conference. To the ladies a tea was given at the home of Mrs. J. W. Henszey on Thursday afternoon. Thursday night a reception in the tent on the campus offered a chance for getting acquainted. Friday the ladies took an all-day automobile ride through the mountains, stopping at a natural cave for lunch. Saturday afternoon was devoted to a picnic at Colerain Forge near Spruce Creek. Those who were able to take in this delightful feature had an opportunity to see some of Pennsylvania's scenery and enjoy a perfect June afternoon out of doors. A picnic supper was served.

The banquet on Friday evening was largely attended and thoroughly enjoyed. Dean Sackett acted as toast-master. A musical program was rendered during dinner, following which Dean Sackett read a telegram from Past-President Charles M. Schwab expressing regret at being unable to attend the conference and speak at the banquet. He then called upon L. H. Morrison who responded by calling attention to the success of the Conference as indicated by the number of representatives of oil-engine builders in attendance. Colonel O. F. Allen was the next speaker and he was followed by George Heath, of Carels Diesel & Steam Engines, Ltd., London, who spoke on the work of the British Diesel Engines Users' Association. He emphasized the necessity of grading and rating Diesel engines and on the question of fuel oils for Diesel engines. There still exists a prejudice against the use of Diesel engines, he pointed out, and it is important to dignify the engine in the profession.

Great credit for the benefit and enjoyment derived from the Conference by all those who attended it is due the local committees having the arrangements in charge: Program and Arrangements, F. G. Hechler, Chairman; Housing and Registration, W. H. Weaver, Chairman; Publicity, C. L. Allen, Chairman; Entertainment, H. A. Everett, Chairman; Exhibits, A. J. Wood, Chairman; Transportation, C. W. Beese, Chairman; Ladies' Program, Mrs. R. L. Sackett, Chairman.

Two More A.S.M.E. Divisions Start National Meetings

Materials Handling Division at Philadelphia and Textile Division at Boston Get Under Way With First National Meetings

FIRST National Meetings of the Materials Handling Division and the Textile Division were held this spring at Philadelphia, Pa., April 23 and 24, and at Boston, Mass., May 22, respectively, and represent the efforts of two more of the Society's professional divisions to develop self-consciousness by holding meetings devoted to problems of special interest. This marks a further advance in the policy of the Society in developing National Meetings as a means of drawing together from considerable distances and for the discussion of technical topics men of similar interests in the profession. Last year the Fuels, Iron and Steel, Wood Industries, Management, Printing Industries, Aeronautic, National Defense, and Machine Shop Practice Divisions held such meetings, thus inaugurating the policy.

MATERIALS HANDLING AT PHILADELPHIA

The First National Meeting of the A.S.M.E. Materials Handling Division, held at Philadelphia, Pa., April 23 and 24, at the Benjamin Franklin Hotel, opened Monday morning with an address by J. G. Hatman, Chairman of the Executive Committee of the Philadelphia Section. This was followed by two technical papers, "Materials Handling Methods at the Eastern Steel Castings Co.," by Frank D. Campbell, chief engineer of the Company, and "Materials Handling Features of the de Lavaud Process of Casting Pipe Centrifugally," by H. A. Hoffer, eastern sales manager of the U. S. Cast Iron Pipe and Foundry Co., Philadelphia.

The afternoon was devoted to a number of inspection trips, one on interior handling in Philadelphia which included the Sears, Roebuck & Co., mail-order merchandizing house, and Atwater Kent Mfg. Co., manufacturers of radio and automotive equipment; one on bulk exterior handling to the Port Richmond coal piers and grain elevators; another on interior handling at the Curtis Publishing Co. and the Victor Talking Machine Co.; one to the plant of the U. S. Cast Iron Pipe & Foundry Co., at Burlington, N. J.; and one to the perishable-products terminal of the Pennsylvania, B. & O., and Reading Railroads.

The banquet on Monday evening was enlivened by the orchestra and Glee Club of the Engineers' Club of Philadelphia. J. G. Hatman, Chairman of the Philadelphia Section, A.S.M.E., acted as toastmaster. The addresses which followed the banquet were on "Red Tape," by C. D. Young, general purchasing agent, Pennsylvania Railroad, and on "The Economic Challenge of Industrial Germany," by E. J. Mehren, vice-president, McGraw-Hill Co., New York.

Tuesday's technical sessions began with a consideration of materials handling in transportation. H. E. Ehlers, Day and Zimmerman, Philadelphia, Pa., was chairman of the morning session at which Willard C. Brinton, president of the Terminal Engineering Co., New York, read an illustrated paper on "Materials Handling on Steamship Piers at Home and Abroad," and G. C. Woodruff, assistant traffic manager, New York Central R.R., spoke on "Modern Methods in Railroad Transportation."

There were two technical sessions on Tuesday afternoon, one on interior handling and the other on bulk handling. George E. Hagemann, managing editor, *Manufacturing Industries*, New York, presided at one session and Nevin E. Funk, assistant chief engineer, Philadelphia Electric Co., presided at the other.

The papers on interior handling were: "Handling Methods and Equipment in a Large Mail-Order House," by H. E. Odenath, chief engineer, Sears, Roebuck & Co., Philadelphia; "Modern Handling in Enameling Work," by Edwin P. Smith, engineer of the National Cash Register Co., Dayton, Ohio; and "Pneumatic Handling of Materials," by Harry S. Parks, of the Holley Pneumatic Systems, Inc., Philadelphia. At the bulk-handling session the papers were "Modern Methods of Handling Coal, Ore, and Other Bulk Materials," by Arthur F. Case, manager, coal and ore division, Wellman, Seaver, Morgan Co., Cleveland, Ohio; "Methods and Equipment for Fuel Handling and Ash Disposal," by James R. McCausland, superintendent, coal bureau and steam-heat section, Philadelphia Electric Co.; and "Handling of Ashes by a Hydraulic System," by Arthur M. Quinn, engineer of the Allen-Sherman-Hoff Co., Philadelphia.

The evening session was held jointly with the American Institute of Mining and Metallurgical Engineers and the National Coal Association. L. Rodman Page, President, Smokeless Operators' Association of West Virginia, was chairman of the meeting.

On account of his inability to be present, Harold V. Coes, vice-president, Belden Mfg. Co., Chicago, Ill., asked Robert M. Gates, manager, industrial division, Superheater Co., New York, to present his paper on "Materials Handling." Mr. Coes said that the problem, stated in its broadest terms, is that we must reduce the number of unskilled workers per industry to the veriest minimum by all the aids and skill at our command, and at the same time increase the productivity of the rest to the maximum, both as to production per dollar of payroll and as to individual earnings, purchasing power. The public, he said, is slowly beginning to appreciate the fact that the cost of living is intimately related to the cost of production and distribution.

Robert Y. Williams, chief engineer, Weston Dodson, Pottsville, Pa., presented a paper entitled, "Requirements for Complete Face Mechanization." The discussion was opened by Cadwallader Evans, Jr., general manager, Hudson Coal Co., Scranton, Pa., and H. F. McCullough, director of engineering, Consolidated Coal Co., Fairmont, West Va., following which there was a general discussion in which many took part.

The Textile Meeting at Boston

The First National Meeting of the A.S.M.E. Textile Division was held under the auspices of the Boston Section on May 22, 1928; nearly 200 engineers from twelve states taking part in the proceedings. Headquarters for the meeting were in the Statler Hotel where the Technical Sessions were held. Reynolds Longfield, industrial engineer of the Bellman Brook Bleachery, Fairview, N. J., in a paper entitled, "Increasing the Capacity of Cotton Padders," described the method which had been devised for increasing the production of a cotton finishing plant in which expansion was desired without the investment of additional capital or equipment. The second paper on "The Value of Water in Textile Mills for Purposes Other than Water Power," by Charles T. Main, Past-President of the Society, discussed methods which would assist in arriving at definite figures for any particular case which might be considered and showed how the availability of water affected the economic location and operation of textile plants. A discussion of paper by H. P. Eddy considered the question of treating the water before used.

The results of a 26-week test on looms with plain and roller bearings were presented in the last paper of the session by George H. Perkins of Boston, consulting engineer, in a paper entitled, "The Comparative Performance of Looms with Plain and Roller Bearings." It was shown that there was a 1.7 per cent increase in output with a reduction of maintenance cost and a 3.6 per cent saving in power. No information as to saving in lubrication was secured, due to difficulties which could not be overcome. Henry M. Burke, engineer of the Mt. Hope Finishing Co., presided at the Technical Session and contributed to the discussion of the papers.

Over 125 took advantage of the afternoon inspection trip to Salem to see the Naumkeag Steam Cotton Co. plant. Transportation arrangements made by the local committee adequately accommodated all. J. Foster Smith personally conducted the group through the plant, and added a great deal to the interest by contributing personal information as to developments from his 50 years' experience as agent.

The evening dinner was held in the Statler Hotel.

P. C. Idell, chairman of the Boston Section, opened the dinner with a few remarks of welcome. James W. Cox, Jr., chairman of the Textile Division, acted as toastmaster, and also contributed some interesting remarks on present operating conditions in the textile industry. J. Foster Smith, agent of the Naumkeag Steam Cotton Co., gave a delightfully interesting talk on the founding of the company in 1839 and its management and operations since that time. Leavelle McCampbell, president of McCampbell & Co., followed Mr. Smith and painted a most interesting trade picture of the principles that govern the sale of cloth. He pointed out to those present that he used the same principles in approaching his problems as the engineers did in mill problems.

Dean D. S. Kimball of Cornell University spoke the final word of the meeting in an inspiring address on the position of the engineer in modern civilization. The closing paragraphs of his address were as follows:

> One of our greatest problems, therefore, is to bring to the aid of the governmental bodies, the technical advice and knowledge of our professional groups. This will be no easy matter, for obviously legislative bodies must be free to work out their own solutions. But nevertheless it would appear to be logical that if all of the professional groups had some means of expressing themselves nationally they could be of great service. The American Bar Association is such a body and one that has done much to advance sane legislation. The American Engineering Council is another similar agency that has already justified its existence. For it should be remembered that the professional groups all together constitute only a small part of our population. The entire body of technically trained scientists and engineers is but a small handful, relatively speaking. Yet this small handful has revolutionized industry and is now reforming our national habits and our economic and social needs.
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> The methods by which all this has been accomplished are also applicable to the solution of some of these economic and social problems. It remains to be seen how these principles can be utilized to these ends. For if government of the people, by the people, and for the people shall fail us, it will not be because of lack of able representatives or of loyalty of the people at large, but because we shall not be able to bring to bear upon these difficult national problems the same kind and degree of technical skill and knowledge that has brought them into being.

Some Educational Statistics

THAT there are sixteen engineering schools in the United States with total enrolments in excess of 1000 and two with enrolments in excess of 2000 is reported in the 1927–28 statistics on 168 engineering colleges which are published in the June issue of the *Journal of Engineering Education*. In point of total enrolment, M.I.T. is our largest engineering college (2250) with Purdue a close second (2226), while in number of regular undergraduates in the four-year course of study, Purdue stands first with 2193 and M.I.T. second with 1965. The total enrolment for the 168 colleges, as of November 1, 1927, was 65,520, an increase of slightly more than 5 per cent over last year's figure. About 31 per cent of these students are registered in electrical engineering and about 17 per cent in mechanical engineering.

In order of number of registrants by courses it is found that electrical engineering comes first, followed by civil, mechanical, industrial, and commercial engineering. Aeronautical engineering stands tenth in order of size with a total registration of 614.

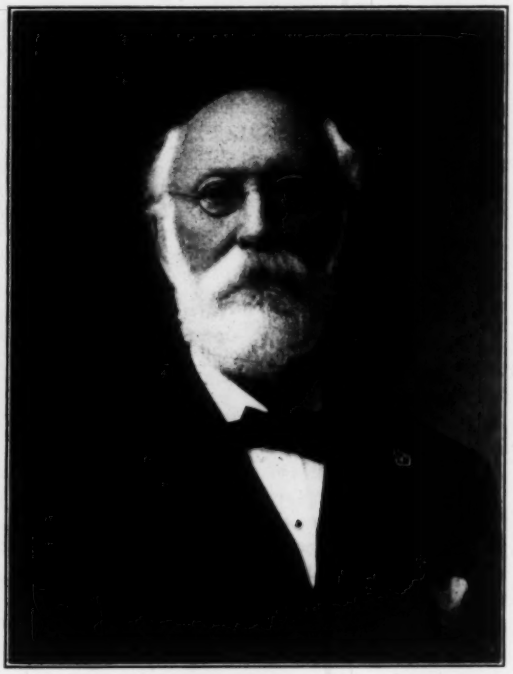
In point of growth over last year's figures, increases are found in most cases, except electrical engineering. In the chemical group, an increase of 98 per cent is noted in electro-chemical engineering, about 55 per cent in chemistry, and about 4 per cent in chemical engineering. Aeronautical engineering shows a growth of 80 per cent over last year, and industrial engineering a growth of about 51 per cent. Mechanical engineering registration figures advanced more than those of electrical, civil, or mining and metallurgical, being about 11 per cent greater this year than last.

Albert Hamilton Emery, His Inventions and Achievements

ALBERT HAMILTON EMERY was born on June 21, 1834, at Mexico, N. Y., and was next to the youngest of eight children. He attended the Mexico Academy, and after studying surveying during the winter of 1851, worked at it throughout the following summer, and in the autumn of 1852 attended the Academy for another three months. In the winter of 1852–1853 he taught school at Union Settlement, and then engaged in surveying a proposed Syracuse & Parishville railroad. He later worked at surveying on a proposed Oswego & Troy railroad.

In the autumn of 1854, desiring to perfect his knowledge of civil engineering, he entered the Rensselaer Polytechnic Institute, in Troy, N.Y., studying for five or six weeks before the close of the winter session. The course covered a period of four years, but Mr. Emery was at the Institute only a little over two years and a half, not including a year when he was out because of an attack of typhoid fever. In 1858 he was graduated with the degree of Civil Engineer in the first section of a class of forty-eight.

The first professional work which engaged his attention was the erection of an unusually high church steeple in his native town of Mexico, N. Y. This was considered by local contractors to be almost impossible, but Mr. Emery did not find the task a difficult one. In the summer of 1859 he went to Washington and took out two patents on cheese presses.



ALBERT HAMILTON EMERY

In the autumn of 1861 Mr. Emery obtained a position as engineer in the Army, a position which could ordinarily be held only by a West Point graduate. From 1861 for several years he spent much time experimenting on guns and projectiles for the War Department.

The next important work undertaken by Mr. Emery was the designing of a new system of scales. Philo Remington, of Ilion, N. Y., advanced the money to build the first three scales under this system. As a result of this work he was asked by the Ordnance Department of the Army to design a large testing machine, and eventually, in December, 1874, he received an order for a 400-ton machine for the War Department.

Parts of the machine were built in different places, the whole being assembled at Watertown Arsenal. In order to build this testing machine it was necessary to design a number of new and novel machines, one of these being a 20-ton scale to standardize weights with which to calibrate the testing machine. The completion of the testing machine was delayed by various difficulties, but in 1879 it was finished and in 1880 went into Government use, constituting a wonderful monument to the genius of the inventor.

The testing machine while in operation at the Arsenal in 1881 was considered part of the exhibits of the Massachusetts Charitable Mechanics Association Fair, held in Boston on Huntington Ave., and as such was awarded a large gold medal of honor, for "That exhibit most conducive to human welfare." A second gold medal was at the same time awarded him on this same machine for "The best scientific apparatus."

The information obtained by this machine has been of inestimable value to engineers and of great influence in many lines of engineering.

In 1882 Mr. Emery moved from Chicopee, Mass., to Stamford, Conn., and the Yale & Towne Mfg. Co. took up the manufacture of his scales, gages, and testing machines. Later this concern, which had purchased his patents, disposed of them in turn to William Sellers & Co.

While with the Yale & Towne Mfg. Co., Mr. Emery designed and built a car dynamometer for the Pennsylvania Railroad Co. to make autographic records of the drawbar pull of locomotives, the dynamometer having a capacity of 28,000 lb. Several years later, in 1902, he was asked by Mr. Vogt, mechanical engineer of the Pennsylvania Railroad, to consider designing and constructing another dynamometer for them, as the old one was entirely inadequate to measure the loads given by the increased size of locomotives. He accordingly designed and built a car dynamometer of 100,000-lb. capacity, the Pennsylvania Railroad designing and building the car therefor. This dynamometer was first put to use in 1906 and is still in service. However, the continued growth of locomotives and the introduction of the electric locomotive made the capacity of this instrument inadequate, and in 1920 Mr. Emery rebuilt certain parts of it to increase its capacity to 150,000 lb. drawbar pull instead of 100,000 lb. In order to calibrate this instrument he found it necessary to design and construct an apparatus for measuring hydraulic pressure up to 3000 lb. per sq. in. to very high accuracy, and he subsequently built a similar instrument with a capacity of 4000 lb. per sq. in. for the National Bureau of Standards.

The next important undertaking which engaged the attention of Mr. Emery was the construction of two testing machines for the Bureau of Standards in Washington. One was for loads of 230,000 lb. tension and compression, and the other for loads of 1,150,000 lb. tension and 2,300,000 lb. compression, on specimens of any length up to 33 ft. The latter is shown in the illustration on the front cover of this issue.

These machines, having the sensitiveness and accuracy of the War Department machine, are in constant service on research work for the Bureau, and through them the Bureau obtains a great amount of very valuable information.

The scales of these machines use an improved form of "Emery" plate fulcrums. E. & T. Fairbanks & Co., of St. Johnsbury, Vermont, saw the scales and believed that these fulcrums could

be adapted to railroad track scales and, working in conjunction with them and with the Pennsylvania Railroad, Mr. Emery designed and built such a scale, which was installed in Tyrone Pa., and was entirely successful in its operations. This type of track scale is largely built by the Pennsylvania Railroad and also used by other roads and large industries.

Very early in his study of the construction of ordnance, Mr. Emery conceived the idea of building guns by hydraulically expanding either a single forging or a series of concentric forgings by the use of hydraulic pressure on the interior, thus putting the required initial strains into the metal instead of employing the usual method of shrinking one part on to another. This method also raises the elastic limit of the metal, and guns so made are much stronger than when the parts are shrunk together. These ideas were embodied in patents which were taken out by him both in this country and in many foreign countries. Mr. Emery tried many times to interest the gun manufacturers and the War and Navy Department in this process, but was unable to do so until in 1918 the Navy Department authorized the construction by him of a 4-in. gun. This was hydraulically expanded, using hydraulic pressures up to 107,000 lb. per sq. in., and tests of this gun have fully proved the value of the process. This process has been adopted by the Navy Department for small guns (3-in. to 6-in.) and in time will probably be adopted for large guns also. It enables gun builders to construct a gun which will be lighter and stronger than the present gun, in less time, from very much less ingot metal, and with very much less machining, largely reducing the cost.

In March, 1875, Mr. Emery married Mrs. Fannie B. Myers, and their son, Albert H. Emery, Jr., has followed his father in engineering work and is carrying on the business started by him.

Mr. Emery passed away on December 2, 1926. He was one of the charter members of the A.S.M.E., a fellow of the A.A.A.S. and a member of the A.S.T.M.

All his work was characterized by his great attention to detail and determination to make his creations as accurate as possible, no matter what the cost in time or endeavor. This took great patience and persistency, but the results obtained have proved the value of his painstaking efforts. Throughout all the vexatious delays which occurred in almost all of his endeavors he was upheld and carried on by his vision of the end to be accomplished and by his unbounded faith and optimism.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Dams

REVIEWED BY WILLIAM HENRY YATES[1]

DIGHE (DAMS). By Engineer Ettore Scimemi. Ulrico Hoepli, Milan, Italy, 1928. Paper 6½ × 9½ in. 512 pp., 442 figs., 5 tables.

WATER, paradoxical as it may seem, is at once the engineer's best friend and his worst enemy. The proper design of dams and appurtenant structures, whether for water supply, water power, or river control, is an ever-present complex problem. The author, therefore, has rendered the engineering profession a notable service by covering so completely and in one volume this very important subject of dams. He has, in fact, made an exhaustive study of the entire subject, including river-control works, and has presented his findings in a masterly manner, as might be expected from the Professor of Hydraulic Engineering at Padua, one of Italy's oldest colleges. It is interesting to find the work of our own Miami Conservation Commission among the river-control works described.

The thoroughness with which this book covers its subject is clearly and concisely portrayed by the way it describes the dams and dikes forming the Ashokan and Kensico reservoirs of the Catskill water-supply system, designed by its chief engineer and the excellent corps of engineers of the Board of Water Supply, City of New York, 1907–1910. The Olive Bridge dam, which is the masonry portion of the Ashokan dam, is so completely described that the method of sealing it with the Hudson shale, forming the bed rock of the valley, is explained in detail. This most important feature of masonry-dam construction frequently is omitted or completely submerged by the analysis of stresses and foundation pressures or other features. The fact remains that we cannot found either a bridge or a dam on good wishes or desires; we must go to rock or a firm foundation. When we have done that, we may concern ourselves with deflections and stresses.

The earth dikes adjoining Olive Bridge dam are also described completely, even to the way the concrete core wall is carried across the pre-glacial gorge under the present bed of Beaver Kill. That gorge, the bottom of which is about 80 feet below the bottom of the core wall on each side of it, is 120 feet wide. It was completely sealed by an arch dam of plain concrete, 20 feet wide at its top, on which rests the extended concrete core wall of the earth dike.

The same close attention to detail extends throughout the book. A reviewer may thus be reminded of the quotation, "Trifles make perfection, and perfection is no trifle," attributed to Michael Angelo.

Fixed dams of the gravity type are well represented by many large masonry dams of that type. Dams of the single-arch type of masonry, multiple-arch dams of reinforced concrete, and also of the reinforced-concrete-beam type, are described. A list would include nearly all the large dams the world over. The multiple-arch dam at Tirso, Sardinia, deserves special men-

[1] Civil Engineer, New York, N. Y. Mem. A.S.C.E.

tion, because of its well-thought-out details and the boldness of its enclosed power plant.

Wasteways and spillways, necessary appurtenant structures to dams, are also well described, and in each case the source of the description, and frequently the designer, are acknowledged. Here again the thoroughness with which the author has prepared his subject is made manifest by his description of the little known and less understood so-called siphon spillway. That type of structure has been used with good results on the New York State Barge Canal, 1905–1914, and more recently by the United States Reclamation Service.

Movable dams of every type are illustrated not only by well-drawn elevations, plans, and sections, but also by good photographs and clear descriptions in the text. The well-designed movable dams on that part of the Mohawk River which made it available for navigation as part of the New York State Barge Canal, 1908–1913, are not shown, but that same type is well illustrated by the movable emergency dams designed to close any of the locks of the better known Panama Canal, and others elsewhere.

Construction methods are clearly shown by some excellent photographs so that "he who runs may read" the general features, and, if interested, return to study the details. One finds for example the merits of cyclopean concrete masonry well presented. Prior to the construction of the Olive Bridge dam it was generally expected that the large derrick-size stones placed in that dam would form about 66 per cent of the entire mass. Measurements proved that they actually formed only one-half that amount or about 33 per cent.

It is refreshing, indeed, to find the relevant mathematics accompanying the description of each structure and not in the back of the book, or in another volume, or promised at some future time. Each problem is completely analyzed, and in some cases both algebraic and graphical solutions are presented.

This book would naturally be of greater value to American engineers if printed in English, because, for example, while the designs of some of the dams described are 20 years old, the details seem to have been missed or not fully appreciated by some of our own American engineers of design.

A word of commendation is due to Mr. John R. Freeman, not only for his energy and enthusiam in the interests of hydraulics but also for his courtesy in placing his copy, probably the only one in the United States, at the disposal of the Society, thus expediting this review by at least six weeks.

Books Received in the Library

ARTIFICIAL SILK, ITS MANUFACTURE AND USES. By Thomas Woodhouse. Isaac Pitman & Sons, New York, 1927. Cloth, 6 × 9 in., 137 pp., illus., $2.

A concise description of artificial silk manufacture. The book gives the history of artificial silk and describes the separation of the cellulose from the raw materials and the making of the yarns. The subsequent processes of winding, warping, sizing, weaving, and knitting are also explained.

THE ELEMENTS OF HYDROLOGY. By Adolph F. Meyer. Second edition. John Wiley & Sons, New York, 1928. Cloth, 522 pp., illus., diagrams, tables, maps, $5.

This book contains chapters on atmosphere, water, precipitation, evaporation and stream flow. This, the second edition, includes about 40 pages of new material, such as rainfall studies by the Miami Conservancy District, and the work by Marston on the area covered by intense rain-storms of short duration. The new evaporation formulas by Horton and Parshall are added and Houk's runoff studies at Dayton are summarized. Vermeule's and the Minnesota runoff formulas are also included.

FIVE HUNDRED SHEET STEEL PRODUCTS AND WHO MAKES THEM. Compiled by Sheet Steel Trade Extension Committee. Pittsburgh, Pa., Sheet Steel Trade Extension Committee, 1927. Boards, 8 × 11 in., 445 pp., $3.

This book gives a brief history of iron and steel, lists of manufacturers of sheet steel, alphabetical lists of fabricators and sheet-steel products with the names of manufacturers. The compilers of this volume have tried to facilitate the work of buyer and seller by making it as easy as possible for the former to quickly locate the latter.

HANDBUCH DER ZEMENTLITERATUR. Compiled by Friedrich Wecke under the direction of Vereins deutscher Portland-Cement-Fabrikanten Charlottenburg, Zementverlag. G.M.B.H., 1927. Cloth, 6 × 9 in., 1447 pp., 40 r.m.

This book is a bibliography of cement, which has been compiled for the Vereins deutscher Portland-Cement-Fabrikanten. It is arranged according to the kind of cement, and most of the articles are annotated. Patents are included. There is a name index, patent index, subject index, and also a list of periodicals and the German libraries in which these periodicals are to be found.

INDUSTRIAL MANAGEMENT. By Richard H. Lansburgh. Second edition. John Wiley & Sons, New York, 1928. Cloth, 6 × 9 in., 509 pp., illus., charts, cloth, $4.50.

This book has been revised in accordance with many changes in management technique and management emphasis. The subject of mechanization has been stressed and the chapters on specialized machinery, material handling, and management control through costs, have been expanded. Chapters on the effects of quantity production and planning, operating the budget and the relationship or management and organization labor have been added.

OUTLINES OF PUBLIC UTILITY ECONOMICS. By Martin G. Glaeser. Macmillan Company, New York, 1927. Cloth, 6 × 9 in., 847 pp., diagrams, charts, tables, $4.25.

This book is the outgrowth of seven years of teaching of the subject of public utilities in university classes. It is intended to present the subject in a way which will introduce the reader to the field in its entirety, because of the great degree of interaction between conditions in the several public-service industries. A selected bibliography has been included, as well as questions for review, and problems.

TWO ESSAYS IN EARLY LOCOMOTIVE HISTORY. By C. F. Dendy Marshall. Locomotive Publishing Co., London, 1928. Cloth, 8 × 11 in., 120 pp., illus., diagrams, 12s. 6d.

This book contains the principal facts, as far as they can be ascertained by the author, on the first hundred locomotives that were actually built. The work of each builder is taken up separately. The question of British locomotives in North America is discussed as well as engines supplied to Canada. About 120 engines were supplied to railways in the United States, but after 1836 the demand for British engines ceased as the railways built their own.

YEAR BOOK ON COAL MINE MECHANIZATION. Compiled by G. B. Southward. American Mining Congress, Washington, 1928. Paper, 6 × 9 in., 273 pp., illus., diagrams, $3.

This Year Book is the result of several years of constant effort on the part of the National Standardization Division of the American Mining Congress, through the Mining and Loading Section, to promote the introduction of mechanical methods of production. It contains history of mechanization; statistics on mechanical loading; mechanized mining in various states; the mechanization survey and reports on it, types of mechanization equipment and a bibliography on coal-mine mechanization.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the Machine Shop Practice section of A.S.M.E. Transactions as published in its new form. This section has been sent to all who registered in the Machine Shop Practice Division. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

MACHINE-SHOP-PRACTICE PAPERS

Progress in Machine-Shop Practice

THIS report of the A.S.M.E. Machine-Shop Practice Division enumerates the economic factors influencing the metal-working industries, and discusses progress as indicated by changes in machine tools in the direction of designs for greater strength and rigidity, higher speeds, the adoption of anti-friction bearings, positive lubrication, hydraulic feeds, etc. It also deals with the development of machine tools for use in the automotive industry, advances in grinding practice, new processes and machines, current standardization and research work, and the outlook for the year 1928. [Paper No. MSP-50-1]

The Development of Machine Tools From a User's Viewpoint

By F. C. SPENCER

Assistant Superintendent, Manufacturing Development, Western Electric Co., Hawthorne Station, Chicago, Ill.

THE author bases his paper on the experiences and practices of the Hawthorne Works of the Western Electric Company, whose development organization is charged with the selection of machine tools. This organization has adopted five standards which affect the design of machine tools: namely, minimum floor-space requirement; elimination of accident hazards by properly designed guards; reduction of physical effort by convenient operating arrangements; cleanliness; and appearance. The effect of these standards on labor is next brought out and is followed by a review of the motor-drive program which has eliminated all but individually motorized machines with motors generally located in the machine base. Examples of several individually motor-driven machines are given. There then follows an account with some details of construction of the development of better and safer punch presses, and machines for drilling small holes in thin metal. The paper ends with a discussion of the possibilities of the hydraulic drive and the importance of giving special attention in the design of all new machine tools to the matter of safety, maintenance, and facility of operation. [Paper No. MSP-50-2]

Symposium on Shop-Equipment Maintenance

FOUR of the contributions to this symposium describe the organization of the departments in whose charge this feature of the manufacturing problem is placed by four great American industrial concerns. The duties and responsibilities of the personnel of these departments are set forth, their relations with the production and other departments of the shops in question are described, the value of the records of maintenance expense is pointed out, and the methods of inspection to determine the need of repairs are explained in detail. One contribution, by J. R. Weaver, deals with the methods used by the Westinghouse Electric & Mfg. Co., at East Pittsburgh, Pa., another by Geo. H. Ashman, with those adopted by the General Electric Company at Schenectady, N. Y., a third, by Wm. Hartman, the organization at the National Cash Register Company's plant at Dayton, Ohio, and a fourth, by C. S. Gotwals, the manner in which the problem is dealt with by the Hess-Bright Mfg. Co., at Philadelphia, Pa.

The remaining contribution, by W. H. Chapman, Harrison, N. J., is more directly related to the fundamental economics of the question of plant maintenance. After defining plant maintenance as he understands it, the author lists twelve items which he later discusses in detail. He attacks the problem from the point of view of accounting practice in the distribution of maintenance expense and its effect upon invested capital, and after laying down some general principles, proceeds to apply the principles to the study of the twelve previously enumerated, showing how the expense involved in each should be distributed. Leaving the economic aspects of the question, the author next sets up a personnel organization and physical layout to handle the problem of general plant maintenance. This is followed by some observations and warnings about the handling of repair orders. Finally, the author returns to the economic phases of his subject and shows how the proper accounting of expenses will affect the return on the investment. [Paper No. MSP-50-3]

Symposium on Hydraulic Feeds for Machine Tools

IN THIS symposium Walter Ferris (Milwaukee, Wis.) shows that the application of hydraulic feed and drive for cutting tools has been made possible by the return to the principles of the hydraulic method as it existed before the introduction of the accumulator, and through the introduction of the multiple-plunger pump. Actual experience during the past five years has developed some peculiarities in the application of hydraulic feeding as compared with geared units, and these are described and discussed, as well as the regulating devices and the various types of the application of hydraulic drive, in particular, variable-delivery pumps with closed hydraulic circuits vs. constant-delivery pumps with bypass circuits.

Waldo J. Guild (Worcester, Mass.), after showing that incompressible fluids have advantages over air for machine-tool drive and operation, shows how the pressure and volume of the pumping unit are determined by the energy required of the device in a unit time, and passes on to a study of the control devices for regulating the volumes of fluid delivered to the driven unit by the throttle valve and bypass valve.

S. Einstein and H. Ernst (Cincinnati, Ohio) describe the operation characteristics of a hydraulic feeding device and the various circuits such as the feeding, rapid traverse, etc. The purpose of the differential pressure-control valve is stated, and the device illustrated and described.

R. M. Galloway (Richmond, Ind.) relates experiences in adapting hydraulic feeds to multiple-spindle drilling machines, and in the development of smaller machines with less expensive pumps.